PROGRAM MANAGER FOR ROCKY MOUNTAIN ARSENAL

U.S. ARMY
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— COMMITTED TO PROTECTION OF THE ENVIRONMENT —

DRAFT FINAL
DETAILED ANALYSIS OF ALTERNATIVES REPORT
VERSION 2.0
WATER DAA
VOLUME V of VII

JULY 1993
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THE CONDUCT OF THE FEASIBILITY STUDY (FS) UNDER CERCLA IS ACCOMPLISHED IN TWO STEPS. THE FIRST STEP, THE DEVELOPMENT AND SCREENING OF ALTERNATIVES (DSA), INVOLVES IDENTIFYING AND SCREENING A BROAD SELECTION OF ALTERNATIVES THAT ACHIEVE THE REMEDIAL ACTION OBJECTIVES (ROAS). THE SECOND STEP IS THE DAA. THE OBJECTIVES OF THE DAA INCLUDE THE FOLLOWING: (1) PROVIDE A MORE DETAILED DEFINITION OF EACH ALTERNATIVE RETAINED IN THE DSA, AS NECESSARY, WITH RESPECT TO THE VOLUMES OR AREAS OF CONTAMINATED MEDIA TO BE ADDRESSED, THE TECHNOLOGIES TO BE USED, AND ANY PERFORMANCE REQUIREMENTS ASSOCIATED WITH THOSE TECHNOLOGIES. (2) ASSESS EACH ALTERNATIVE AGAINST THE DAA EVALUATION CRITERIA IDENTIFIED IN THE NATIONAL CONTINGENCY PLAN AND DEFINED IN U.S. EPA GUIDANCE (EPA 1988). (3) PERFORM A COMPARATIVE ANALYSIS AMONG THE ALTERNATIVES TO EVALUATE THE RELATIVE PERFORMANCE OF EACH ALTERNATIVE WITH RESPESCT TO EACH EVALUATION CRITERION. (4) SELECT A PREFERRED ALTERNATIVE FOR EACH MEDIUM GROUP BASED ON THE COMPARATIVE ANALYSIS. THE DAA REPORT CONSISTS OF SEVEN VOLUMES. VOLUME I - EXECUTIVE

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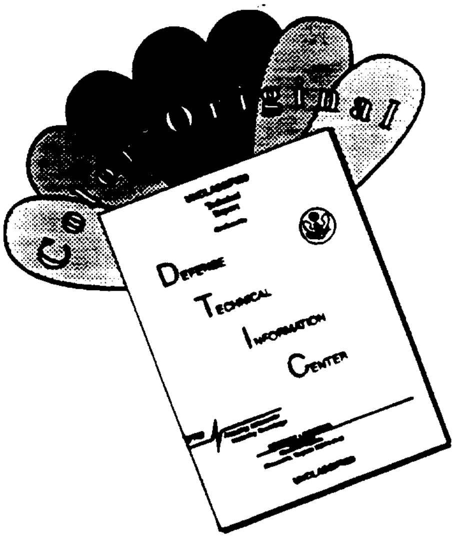

TECHNICAL SUPPORT FOR ROCKY MOUNTAIN ARSENAL

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DIRECTORY,
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LIST OF ACRONYMS AND ABBREVIATIONS

µg/l	micrograms per liter
3-D	three-dimensional
ACGIH	American Conference of Governmental Industrial Hygienists
ACM	asbestos–containing material
AMC	Army Materiel Command
AOC	Area of Contamination
AOPs	advanced oxidation processes
AR	Army Regulations
ARARs	applicable or relevant and appropriate requirements
Army	U.S. Army
atm-m^3/mol	atmospheres per cubic meters per mole
ATP	Anaerobic Thermal Processor
ATSDR	Agency for Toxic Substances and Disease Registry
BCY	bank cubic yard
BDAT	best demonstrated available technology
BEST	Basic Extraction Sludge Treatment
BFI	Browning Ferris Industries
BOD	Biological Oxygen Demand
BTEX	benzene, toluene, ethylbenzene, and xylenes
BTU	British thermal unit
CAMU	Corrective Action Management Unit
CAR	Contamination Assessment Report
CCA	chromated-copper-arsenate
CCR	Code of Colorado Regulations
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfm	cubic feet per minute
CFR	Code of Federal Regulations
CLC2A	Chloroacetic Acid
cm/sec	centimeters per second
cm^2	centimeters squared
COC	contaminant of concern
CPE	chlorinated polyethylene
CPRP	Chemical Personnel Reliability Program
CRL	certified reporting limit
CSI	Conservation Services, Inc.
CSPE	chlorosulfonated polyethylene
CWA	Clean Water Act
CY	cubic yards
DA	Department of the Army
DAA	Detailed Analysis of Alternatives
DADS	Denver Arapahoe Disposal Service, Inc.
db(A)	decibels
DBCP	dibromochloropropane
DCPD	dicyclopentadiene
DDE	dichlorodiphenylethane
DDT	dichlorodiphenyltrichloroethane
DHHS	Department of Health and Human Services
DIMP	diisopropylmethyl phosphorate
DNAPL	dense nonaqueous phase liquid
DOD	Department of Defense

DOT	Department of Transportation
DRE	destruction removal efficiency
DRMO	Defense Reutilization and Marketing Office
DSA	Development and Screening of Alternatives
EA	Endangerment Assessment
Ecology	U.S. Ecology, Inc.
EDSVEP	Enhanced Deep Soil Vapor Extraction Process
ENSCO	Environmental Systems Company
Envirosafe	Envirosafe Services of Idaho, Inc.
EOD	Explosive Ordnance Disposal
EPA	U.S. Environmental Protection Agency
ERC	Ecological Risk Characterization
ESSVEP	Enhanced Surface Soil Vapor Extraction Process
ETTS	Ecotechniek Thermal Treatment System
FC2A	fluoroacetic acid
FFA	Federal Facility Agreement
FML	flexible membrane liner
fpm	feet per minute
FRP	fiber - reinforced plastic
FS	feasibility study
ft/day	feet per day
ft	feet or foot
ft^3	cubic feet
GAA	granulated activated alumina
GAC	granular activated carbon
GB	isopropylmethylphosphonosfluoridate (nerve agent-sarin)
gpm	gallons per minute
H:V	horizontal to vertical
H_2O_2	hydrogen peroxide
HBr	hydrogen bromide
HCCPD	hexachlorocyclopentadiene
HCL	hydrochloric acid
HCPD	Hexachloro pentadiene
HDPE	high-density polyethylene
HE	high explosive
HEP	habitat evaluation protocol
HEPA	high efficiency particulate
HF	hydrofluoric acid
Hg	mercury
HHEA	Human Health Exposure Assessment
HHRC	Human Health Risk Characterization
HI	hazard index
ICP	inductively coupled plasma
ICS	Irondale Containment System
IDLH	Immediately Dangerous to Life and Health
IEA	Integrated Endangerment Assessment
IITRI	IIT Research Institute
IRA	interim response action
IT	International Technology
IWT	International Waste Technologies
K_{oc}	partition coefficient
kw	Kilowatt
kWh	Kilowatt hour

L	Lewisite
lbs	pounds
lbs/acre	pounds per acre
LCY	loose cubic yards
LCY/hr	loose cubic yards per hour
LDR	land disposal restriction
LF	Linear Foot
LNAPL	light nonaqueous phase liquid
LT^3	Low-Temperature Thermal Treatment
LTTA	Low-Temperature Thermal Aeration
mg/l	micrograms per liter
mg/cm^3	milligrams per cubic centimeter
mg/m^3	milligram per cubic meter
mg/kg	milligrams per kilogram
mg/l	microgram per liter
MKE	Morrison–Knudsen Engineering
ml/g	milliliters per gram
mm	millimeters
MMBTU	million British thermal units
mph	miles per hour
MTR	minimum technology requirement
NaOH	sodium hydroxide
NBCS	North Boundary Containment System
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NWBCS	Northwest Boundary Containment System
O&M	operations and maintenance
OAS	Organizations and State
°C	degrees Centigrade
OCP	organochlorine pesticides
OCPD	dicyclopentadiene
°F	degrees Fahrenheit
OPHGB	organophosphorus compounds, GB-agent related
OPHP	organophosphorus Compounds; pesticide related
OSCH	organosulfur compounds; herbicide related
OSCM	organosulfur Compounds; mustard agent related
OSHA	Occupational Health and Safety Administration
PAHs	polynuclear aromatic hydrocarbons
PBC	probabalistic biota criteria
PCB	polychlorinated biphenyls
pcf	pounds per cubic foot
PCP	pentachlorophenol
PEC	plume evaluation criteria
PKPP	potassium pyrophosphate
ppb	parts per billion
PPE	personal protective equipment
PPLV	preliminary pollutant limit value
ppm	parts per million
PRG	preliminary remediation goal
psi	pounds per square inch
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
RAO	remedial action objectives

RCRA	Resource Conservation and Recovery Act
RF	radio frequency
RI	Remedial Investigation
RISR	Remedial Investigation Summary Report
RMA	Rocky Mountain Arsenal
ROD	Record of Decision
RPO	representative process option
SACWSA	South Adams County Water and Sanitation District
SAR	Study Area Report
SARA	Superfund Amendments and Reauthorization Act
SCC	Secondary Combustion Chamber
SEC	Site evaluation criteria
SF	square feet
Shell	Shell Oil Company
SHO	Semivolatile halogenated organics
SITE	Superfund Innovative Technology Evaluation
STC	Silicate Technology Corporation
SVE	soil vapor extraction
SVOCs	semivolatile organic compounds
SY	square yards
T.DI.	Services HT-5
TBC	to be considered
TCE	trichloroethylene
TCLP	Toxicity Characteristic Leaching Procedure
TEA	triethylamine
TEC	Target Effluent Concentrations
TIS	transportable incineration system
TMV	toxicity, mobility, and volume
TOC	total organic carbon
tpd	tons per day
TSCA	Toxic Substances Control Act
TSD	Treatment Storage and Disposal
TSMG	two-step geometric mean
USCS	Unified Soil Classification System
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USPCI	U.S. Pollution Control, Inc.
UV	ultraviolet
UXO	unexploded ordnance
VAO	volatile aromatic organic compounds
VHC	volatile hydrocarbon compounds
VHO	volatile halogenated organics
VOC	volatile organic compound
VX	ethyl s-dimethyl aminoethyl methyl phosphonothiolate (nerve agent)
WES	Waterways Experimental Station

1.0 INTRODUCTION

1.1 BACKGROUND

The Detailed Analysis of Alternatives for the water medium (Water DAA) at Rocky Mountain Arsenal (RMA) is the final stage of the Water Feasibility Study (Water FS) and is a follow-on to the Development and Screening of Alternatives for the water medium (Water DSA) (EBASCO 1992). This document provides significantly greater detail than the Water DSA, incorporating groundwater modeling and treatability study results as well as performing additional statistical analysis of chemical data and an integrated analysis of all alternatives proposed for the soils, water, and structures media to ensure that they are compatible and work together to achieve the remedial action objectives (RAOs) (see Executive Summary Volume) established for RMA. The analysis of alternatives in this document was conducted according to U.S. Environmental Protection Agency (EPA) guidance (EPA-OERR 1988).

1.2 DSA SUMMARY

The Water DSA identified five different plume groups and retained a range of treatment alternatives including no action, containment, and treatment options (Figures 1.2-1 through 1.2-5) for each as a result of the screening process. Incorporated into many of the alternatives are the existing boundary containment systems and groundwater-related interim response actions (IRAs) (Table 1.2-1). The plume groups, further discussed in Section 3.1, are the following: Northwest Boundary, Western, North Boundary, Basin A, and South Plants.

Both No Action and Continued Existing Action alternatives were retained for each of the plume groups in the Water DSA. The No Action alternative does not involve any remedial activities or restrictions at a site. Therefore, activities that are currently in place, such as the boundary containment systems and IRAs, would be discontinued. The Continued Existing Action alternative involves continued implementation of the RMA access and use restrictions stipulated in the Federal Facility Agreement (FFA), continued operation of the existing boundary containment and treatment systems, the IRAs currently in place, and any planned additions or upgrades to those systems. The provisions of the Continued Existing Action alternative are

included implicitly in all other alternatives, which represent additional remedial measures beyond this alternative.

For convenient identification, each alternative is designated as follows: the first one or two letters in the designation identifies the plume group (i.e., N for North Boundary, NW for Northwest Boundary, W for Western, A for Basin A, SP for South Plants); the next letter, "C" or "T," identifies the alternative as a groundwater control or treatment alternative, respectively. Finally, a number is appended to these letters that reflects the order in which the alternatives are described. The first two control alternatives described for each plume group are always No Action and Continued Existing Action. For example, in the Northwest Boundary Plume Group, the No Action and Continued Existing Action alternatives are designated as NWC-1 and NWC-2, respectively. The retained alternatives are briefly discussed below.

The two alternatives retained for the Northwest Boundary (Figure 1.2-1) and Western Plume Groups (Figure 1.2-2) were No Action and Continued Existing Action. The Water DSA evaluation determined that for both of these plume groups additional on-post groundwater capture and treatment would be of minimal benefit.

In addition to the No Action and Continued Existing Action alternatives, two different groundwater control alternatives were retained in the Water DSA for the North Boundary plume Group (Figure 1.2-3). These were Alternatives NC-3, which consists of capture and extraction of the North Plants Plume in the source area followed by piping to the North Boundary Containment System (NBCS) combined with extraction, treatment, and reinjection of the Basins C and F Plume, and Alternative NC-6, which involves the same extraction system in North Plants combined with installation of a slurry wall and cap in the Basins C and F area. The treatment alternatives retained for the Basins C and F Plume were granular activated alumina (GAA) adsorption, granular activated carbon (GAC) adsorption, air stripping combined with GAC adsorption, and oxidation.

In addition to the No Action and Continued Existing Action alternatives, two different groundwater control alternatives were retained in the Water DSA for the Basin A Plume Group (Figure 1.2-4). Alternative AC-3 involves extraction of water from all Basin A plumes followed by treatment and reinjection. Retained treatment alternatives for AC-3, in addition to continued operation of the Basin A Neck IRA system, were GAC adsorption combined with air stripping and oxidation followed by air stripping and GAC adsorption. Alternative AC-7, a dewatering alternative, employs a cap combined with extraction and treatment of water at the Basin A Neck IRA system.

In addition to the No Action and Continued Existing Action alternatives, four different groundwater control configurations were retained for the South Plants Plume Group (Figure 1.2-5). Alternative SPC-3 employs extraction from all four plumes in this plume group for aboveground treatment, while Alternative SPC-5 involves extraction followed by aboveground treatment for all plumes except for the South Tank Farm Plume, which is to be treated by in situ biodegradation. Under Alternative SPC-5, as in one scenario of Alternative SPC-3, the South Tank Farm Plume is treated separately from the other plumes: in Alternative SPC-3 direct biological treatment is followed by GAC adsorption, and in Alternative SPC-5 in situ biodegradation is combined with aboveground oxidation. Treatment alternatives that were retained for the remaining plumes are oxidation combined with GAC adsorption and air stripping followed by GAC adsorption. Both Alternative SPC-6 and Alternative SPC-7 are dewatering alternatives involving extensive extraction of the South Plants groundwater mound. Alternative SPC-6, however, includes extraction and reinjection only, while Alternative SPC-7 includes installation of a cap. The treatment process retained for both alternatives are oxidation combined with GAC adsorption and air stripping followed by GAC adsorption.

1.3 CHANGES FROM THE WATER DSA

The Water DAA incorporates new groundwater analytical and hydraulic data as well as additional information obtained through groundwater modeling and treatability studies. In addition, procedures were established to simplify the decision-making process as to whether a plume

should be considered for on-post treatment and, if so, what type of treatment system would be appropriate. Plume maps used during the DSA were updated using 1989–92 water-quality data.

1.3.1 Evaluation Criteria for On-post Groundwater

Three different sets of criteria were established for on-post plume evaluation, treatment system design, and system performance evaluation in the DAA. These are the plume evaluation criteria (PECs), design treatment goals (DTGs), and target effluent concentrations (TECs). Each of these sets of criteria serves distinct purposes, as identified below:

- PECs are used as a final screening tool to determine whether a plume that has tentatively been identified as a candidate for treatment has contaminant concentrations that justify the treatment.
- DTGs are simply the design goals for on-post treatment systems; they do not represent the enforceable effluent concentrations.
- TECs are enforceable effluent concentrations that have been established for each of the on-post systems.

1.3.1.1 Plume Evaluation Criteria

Each contaminant plume was re-evaluated in the Water DAA to determine whether it should be a candidate for extraction and treatment. PECs were established as a final screening tool for plumes that had been identified as potential candidates for treatment based on the hydrogeological analysis. PECs represent concentration values that are either ten times a drinking water standard, ten times the off-post preliminary remediation goals (PRGs) defined for each individual compound or ten times the calculated risk level for drinking water containing compounds that do not have established standards or off-post PRGs. The drinking water standards used as a basis for the evaluation are those listed in the Water DSA (Volume I, Table 1.3-2) and include federal Primary Drinking Water Standards, Colorado primary drinking water regulations, and Colorado groundwater standards. Some of the Water DSA values were updated to reflect changes in the PRGs and drinking water standards. Table 1.3-1 presents the applicable PEC values. All plumes were re-evaluated against the PECs using the most recent groundwater data available. Any plume

with a contaminant that exceeds PECs was evaluated for the full range of alternatives. PECs, like site evaluation criteria for soils, are indicator values that trigger additional evaluation. If contaminant values are less than the PECs, it is extremely doubtful that additional control and treatment would provide significant contaminant reduction within the overall plume. All plumes were re-evaluated against the PECs using the most current groundwater data available, and it was determined that the boundary containment systems that currently exist are providing adequate protection of human health and the environment.

1.3.1.2 Design Treatment Goals

DTGs, which represent drinking water standards, off-post PRGs, or risk-based concentration values, were established for the proposed on-post treatment alternatives. These values (Table 1.3-2) were established as design goals only, not as enforceable effluent standards.

1.3.1.3 Target Effluent Concentrations

TECs were established in the DSA as enforceable effluent criteria for on-post treatment systems. Although different TEC values may be applied to different systems, it was decided to use the same TECs for all of the treatment systems proposed in the DAA due to common reinjection systems. The selected TECs (Table 1.3-3) represent concentrations that are twice the drinking water standard, twice the off-post PRGs or twice the risk-based values. The applicability and selection of TECs are further discussed in Section 2.3.

1.3.2 Reduced Plume Flow Rates and Concentrations

Groundwater flow modeling, conducted during the DAA for the Basin A and South Plants areas to assist in the evaluation of remedial alternatives, typically showed significantly lower flow rates in all plumes than the Water DSA estimates indicated (see Sections 7 and 8)(EBASCO 1993). In addition, further statistical analysis of the most recent chemical data (1988–92) show lower contaminant concentrations than previously estimated. The two-step geometric mean (TSGM) values for wells in the immediate upgradient vicinity of the groundwater control systems were used to estimate the concentrations for all treatment alternative evaluations. The estimated

concentrations are flow-weighted between plumes. The lower groundwater extraction rates and contaminant concentrations in some cases led to reconfiguration of control and treatment systems. Specific changes for each plume group are described below.

1.3.3 Plume-Group-Specific Changes

No changes were made to alternatives or conclusions for the Northwest Boundary Plume Group or the Western Plume Group. For the North Boundary Plume Group, the intercept system for the North Plants Plume was eliminated because contaminant concentrations did not exceed PECs. The treatment plant in the Basins C and F area was eliminated because of low predicted extraction rates from that control system; extracted Basins C and F water is now to be piped either to the NBCS or the Basin F Groundwater/Basin A Neck IRA treatment system for treatment.

The Basin A and South Plants Plume Groups extraction rates were estimated through groundwater modeling to be significantly lower than the previous Water DSA estimates. Additional statistical analysis utilizing TSGMs of recent chemical data from upgradient wells also indicates lower contaminant concentrations. The primary change in the control/treatment alternatives in the Basin A and South Plants areas was to use a contaminant mass reduction approach to extract and treat the most contaminated central portions of each plume rather than to use intercept systems for plume control. Mass reduction, i.e., the location of extraction wells along the more contaminated central portions of plumes, is a more aggressive approach that actively addresses the goal of reducing contaminant toxicity, mobility, and volume (TMV).

In addition, water in the South Plants Southwest Plume was found not to exceed PECs, and this plume was consequently not considered for treatment. The other South Plants plume combinations remain as they were in the Water DSA, except that Alternatives SPC-6 and SPC-7 involve a phased approach in which the South Plants North Source, the Southeast, and the South Tank Farm Plumes are pumped during the initial 10-year period to achieve mass reduction as

other activities in South Plants are taking place, followed by dewatering of the whole South Plants area.

1.4 ORGANIZATION OF THE DOCUMENT

Each section of this document describes both general FS procedures and site-specific information. It is organized as follows.

Section 2 outlines Water DAA objectives, PRGs, and the interaction between the water, soil, and structures media, and describes the detailed analysis and alternatives selection process. Section 3 provides background information for control and treatment technologies, including a discussion of the plume groups, and models used.

Sections 4 through 8 address each of the five plume groups individually by providing descriptions and individual detailed analysis for each alternative. Section 9 provides a comparative analysis of the alternatives and presents the preferred alternatives. Section 10 discusses combining the preferred alternatives in the Basin A and South Plants Plume Groups and treating them at a Basin A/South Plants combined treatment plant.

Table 1.2-1 Summary of Groundwater-Related Interim Response Actions[1]

Page 1 of 1

IRA	Objective	Completion Date or Anticipated Completion Date for Construction
• Groundwater Intercept and Treatment System North of RMA	• Eliminate much of the potential for any future alluvial groundwater plumes north of RMA.	December 1992
• Improvement of the North Boundary Containment System and Evaluation of Existing Boundary Containment Systems	• Evaluate and improve, as necessary, all RMA boundary systems and eliminate off-post migration of contaminated alluvial groundwater above compliance levels.	December 1988 - September 1993
• Groundwater Intercept and Treatment System North of Basin F (Basin F Groundwater IRA)	• Intercept and treat contaminated alluvial groundwater originating from the Basin F area.	September 1990
• Closure of Abandoned Wells at RMA	• Identify, locate, examine, and properly close old or unused wells at RMA to prevent migration of contamination between aquifers.	February 1990
• Groundwater Intercept and Treatment System in the Basin A Neck Area (Basin A Neck IRA)	• Intercept and treat contaminated groundwater in the alluvial aquifer between Basins A and F.	July 1990
• Remediation of other Contamination Sources (Hot Spots)	• Mitigate the threat of releases from selected hot spots contamination source.	March 1994
Hot Spots Identified Include:		
• Lime Settling Basins	• Mitigate the threat of migration of contaminants to the underlying groundwater.	June 1993
• M-1 Settling Basins	• Mitigate any potential for infiltration of contaminants to groundwater and preclude potential for volatile emissions.	December 1992
• Motor Pool Area - Trichloroethylene Plume	• Intercept and treat contaminated alluvial groundwater originating at the motor pool area and mitigate soil contamination to prevent continued migration to groundwater.	September 1991
• Rail Classification Yard - Dibromochloropropane Plume	• Intercept and treat contaminated alluvial groundwater originating at the Rail Classification yard.	September 1991
• Shell Trenches	• Mitigate the migration of contaminants to the underlying groundwater.	November 1991
• South Tank Farm Plume	• Intercept and treat contaminated groundwater originating at the tank farm.	March 1994
• Pretreatment of CERCLA Liquid Waste (CERCLA Wastewater Treatment Plant)	• Treat wastewater resulting from CERCLA-related activities at RMA.	July 1992

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[1] Source: Final Remedial Investigation Summary Report (RISR) (EBASCO 1992/RIC 92017R01)

CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
IRA	Interim Response Action
RMA	Rocky Mountain Arsenal

Table 1.3-1 Plume Evaluation Criteria for Groundwater * Page 1 of 2

Chemical Group/Compound	Design Treatment Goal (µg/l)	Reference
Volatile Halogenated Organics (VHOs)		
1,2-Dichloroethane	50	1
1,1-Dichloroethylene	70	1
1,2-Dichloroethylene (trans)	700	2
1,1,1-Trichloroethane	2,000	1
1,1,2-Trichloroethane	30	2
Carbon tetrachloride	50	1
Chlorobenzene	250	3
Chloroform	150	3
Methylene chloride	50	1
Tetrachloroethylene	50	1
Trichloroethylene	50	1
Volatile Hydrocarbon Compounds (VHCs)		
Dicyclopentadiene	460	3
Volatile Aromatic Organics (VAOs)		
Benzene	50	1
Ethylbenzene	6800	2
Xylenes	100,000	1
Toluene	10,000	1
Organosulfur Compounds: Mustard Agent Related (OSCMs)		
1,4-Oxathiane	1,600	3
Dithiane	180	3
Organosulfur Compounds: Herbicide Related (OSCHs)		
Chlorophenylmethyl sulfide	300	3
Chlorophenylmethyl sulfone	360	3
Chlorophenylmethyl sulfoxide	360	3
Organophosphorus Compounds: Isopropylmethyl Phosphonofluoridate (GB) Agent Related (OPHGBs)		
Diisopropylmethyl phosphonate (DIMP)	6,000	3
Isopropylmethyl phosphonate (IMPA)	7,000	4

µg/l Microgram per liter

Table 1.3-1 Plume Evaluation Criteria for Groundwater*

Chemical Group/Compound	Plume Evaluation Criteria (µg/l)	Reference
Organophosphorus Compounds: Pesticide Related (OPHPs)		
Atrazine	40.3	3
Malathion	1,000	3
Semivolatile Halogenated Organics (SHOs)		
1,3-Dichlorobenzene	65	3
Hexachlorocyclopentadiene	2.3	3
Dibromochloropropane (DBCP)	2	1
Organochlorine Pesticides (OCPs)		
Aldrin	0.5	3
Chlordane	2.0	1
Dichlorodiphenylethane (DDE)	0.54	3
Dichlorodiphenyltrichloroethane (DDT)	1.0	2
Dieldrin	0.5	3
Endrin	2.0	3
Isodrin	0.6	3
Arsenic	500	1
Mercury	20	1
Inductively Coupled Plasma (ICP) Metals		
Cadmium	50	1
Chromium	1,000	1
Lead	500	1

µg/l Microgram per liter

* Plume evaluation criteria values represent 10 times the standards presented in the referenced document.
1) EPA National Primary Drinking Water Regulations (40 Code of Federal Regulations (CFR) 141)
2) Colorado Ground Water Standards (5 CCR 1002-8)
3) Primary Remediation Goals, Off-Post Operable Unit Endangerment Assessment/Feasibility Study, Harding Lawson Associates, March 1992 (RIC92094R02)
4) EPA Health Advisory (EPA, 1993)

Table 1.3-2 Design Treatment Goals for Groundwater

Page 1 of 2

Chemical Group/Compound	Design Treatment Goal DTG (µg/l)	Reference
Volatile Halogenated Organics (VHOs)		
1,2-Dichloroethane	5	1
1,1-Dichloroethylene	7	1
1,2-Dichloroethylene (trans)	70	2
1,1,1-Trichloroethane	200	1
1,1,2-Trichloroethane	3	2
Carbon tetrachloride	5	1
Chlorobenzene	25	3
Chloroform	15	3
Methylene chloride	5	1
Tetrachloroethylene	5	1
Trichloroethylene	5	1
Volatile Hydrocarbon Compounds (VHCs)		
Dicyclopentadiene	46	3
Volatile Aromatic Organics (VAOs)		
Benzene	5	1
Ethylbenzene	680	2
Xylenes	10,000	1
Toluene	1,000	1
Organosulfur Compounds: Mustard Agent Related (OSCMs)		
1,4-Oxathiane	160	3
Dithiane	18	3
Organosulfur Compounds: Herbicide Related (OSCHs)		
Chlorophenylmethyl sulfide	30	3
Chlorophenylmethyl sulfone	36	3
Chlorophenylmethyl sulfoxide	36	3
Organophosphorus Compounds: Isopropylmethyl Phosphonofluoridate (GB) Agent Related (OPHGBs)		
Diisopropylmethyl phosphonate (DIMP)	600	3
Isopropylmethyl phosphonate (IMPA)	700	4

µg/l Microgram per liter

1) EPA National Primary Drinking Water Regulations (40 Code of Federal Regulations (CFR) 141)
2) Colorado Ground Water Standards (5 CCR 1002-8)
3) Primary Remediation Goals, Off-Post Operable Unit Endangerment Assessment/Feasibility Study, Harding Lawson Associates, March 1992 (RIC92094R02)
4) Health Advisory (EPA, 1993)

Table 1.3-2 Design Treatment Goals for Groundwater

Chemical Group/Compound	Design Treatment Goal DTG (µg/l)	Reference
Organophosphorus Compounds: Pesticide Related (OPHPs)		
Atrazine	4.03	3
Malathion	100	3
Semivolatile Halogenated Organics (SHOs)		
1,3-Dichlorobenzene	6.5	3
Hexachlorocyclopentadiene	0.23	3
Dibromochloropropane (DBCP)	0.2	1
Organochlorine Pesticides (OCPs)		
Aldrin	0.05	3
Chlordane	2	1
Dichlorodiphenylethane (DDE)	0.054	3
Dichlorodiphenyltrichloroethane (DDT)	0.1	2
Dieldrin	0.05	3
Endrin	0.20	3
Isodrin	0.06	3
Arsenic	50	1
Mercury	2	1
Inductively Coupled Plasma (ICP) Metals		
Cadmium	5	1
Chromium	100	1
Lead	50	1

µg/l Microgram per liter

1) EPA National Primary Drinking Water Regulations (40 Code of Federal Regulations (CFR) 141)
2) Colorado Ground Water Standards (5 CCR 1002-8)
3) Primary Remediation Goals, Off-Post Operable Unit Endangerment Assessment/Feasibility Study, Harding Lawson Associates, March 1992 (RIC92094R02)
4) Health Advisory (EPA, 1993)

Table 1.3-3 Target Effluent Concentrations for Groundwater

Page 1 of 2

Chemical Group/Compound	Target Effluent Concentration (µg/l)	Reference
Volatile Halogenated Organics (VHOs)		
1,2-Dichloroethane	10	1
1,1-Dichloroethylene	14	1
1,2-Dichloroethylene (trans)	140	2
1,1,1-Trichloroethane	400	1
1,1,2-Trichloroethane	6	2
Carbon tetrachloride	10	1
Chlorobenzene	50	3
Chloroform	30	3
Methylene chloride	10	1
Tetrachloroethylene	10	1
Trichloroethylene	10	1
Volatile Hydrocarbon Compounds (VHCs)		
Dicyclopentadiene	92	3
Volatile Aromatic Organics (VAOs)		
Benzene	10	1
Ethylbenzene	1,360	2
Xylenes	20,000	1
Toluene	2,000	1
Organosulfur Compounds: Mustard Agent Related (OSCMs)		
1,4-Oxathiane	320	3
Dithiane	36	3
Organosulfur Compounds: Herbicide Related (OSCHs)		
Chlorophenylmethyl sulfide	60	3
Chlorophenylmethyl sulfone	72	3
Chlorophenylmethyl sulfoxide	72	3
Organophosphorus Compounds: Isopropylmethyl Phosphonofluoridate (GB) Agent Related (OPHGBs)		
Diisopropylmethyl phosphonate (DIMP)	1,200	3
Isopropylmethyl phosphonate	1,400	4

µg/l Microgram per liter

Table 1.3-3 Target Effluent Concentrations for Groundwater

Page 2 of 2

Chemical Group/Compound	Target Effluent Concentration (TEC) (µg/l)	Reference
Organophosphorus Compounds: Pesticide Related (OPHPs)		
Atrazine	8.06	3
Malathion	200	3
Semivolatile Halogenated Organics (SHOs)		
1,3-Dichlorobenzene	12.1	3
Hexachlorocyclopentadiene	0.46	3
Dibromochloropropane (DBCP)	0.4	1
Organochlorine Pesticides (OCPs)		
Aldrin	0.1	3
Chlordane	4	1
Dichlorodiphenylethane (DDE)	0.108	3
Dichlorodiphenyltrichloroethane (DDT)	0.2	2
Dieldrin	0.10	3
Endrin	0.4	3
Isodrin	0.12	3
Arsenic	100	1
Mercury	4	1
Inductively Coupled Plasma (ICP) Metals		
Cadmium	10	1
Chromium	200	1
Lead	100	1

µg/l Microgram per liter

1) EPA National Primary Drinking Water Regulations (40 Code of Federal Regulations (CFR) 141)
2) Colorado Ground Water Standards (5 CCR 1002-8)
3) Primary Remediation Goals, Off-Post Operable Unit Endangerment Assessment/Feasibility Study, Harding Lawson Associates, March 1992 (RIC92094R02)
4) Health Advisory (EPA 1993)

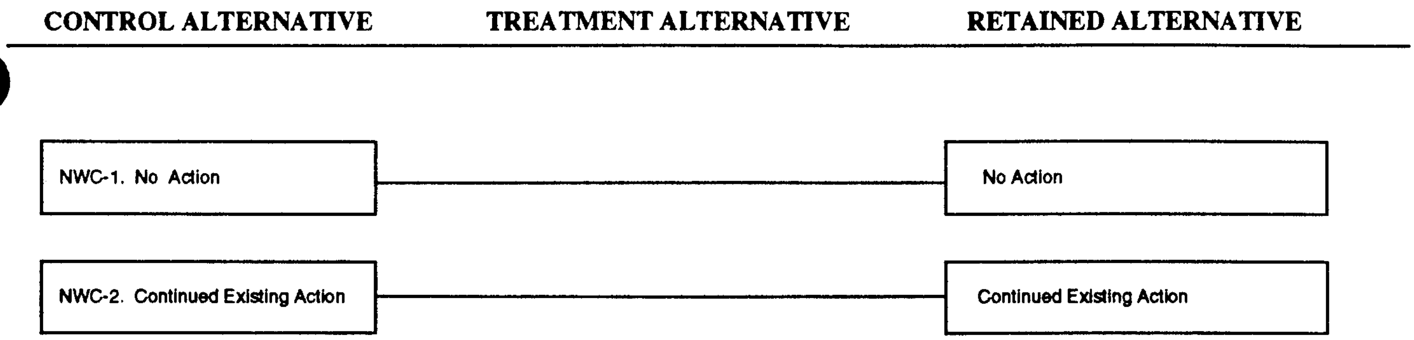
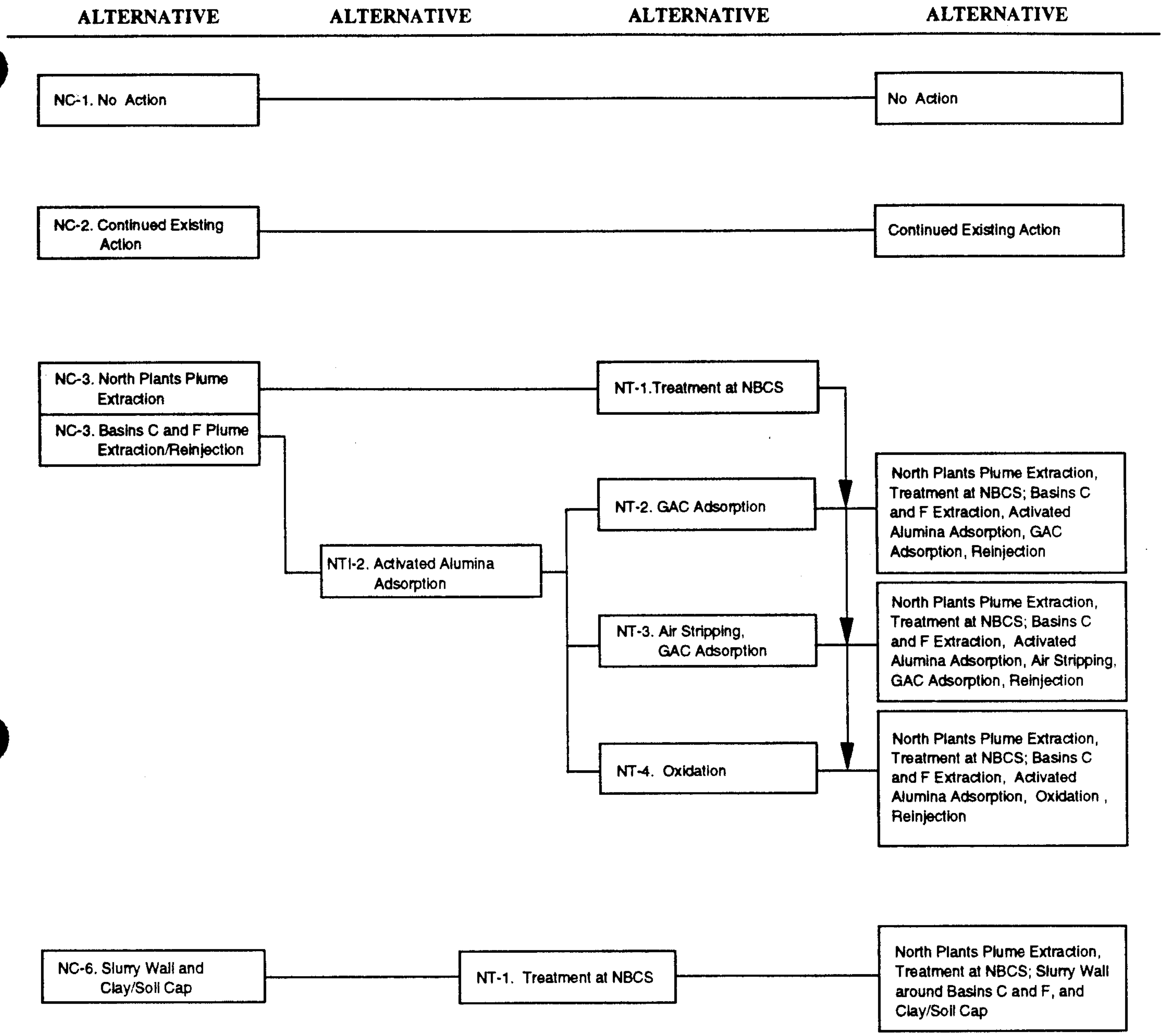


Figure 1.2-1 Northwest Boundary Plume Group Alternatives Retained in DSA

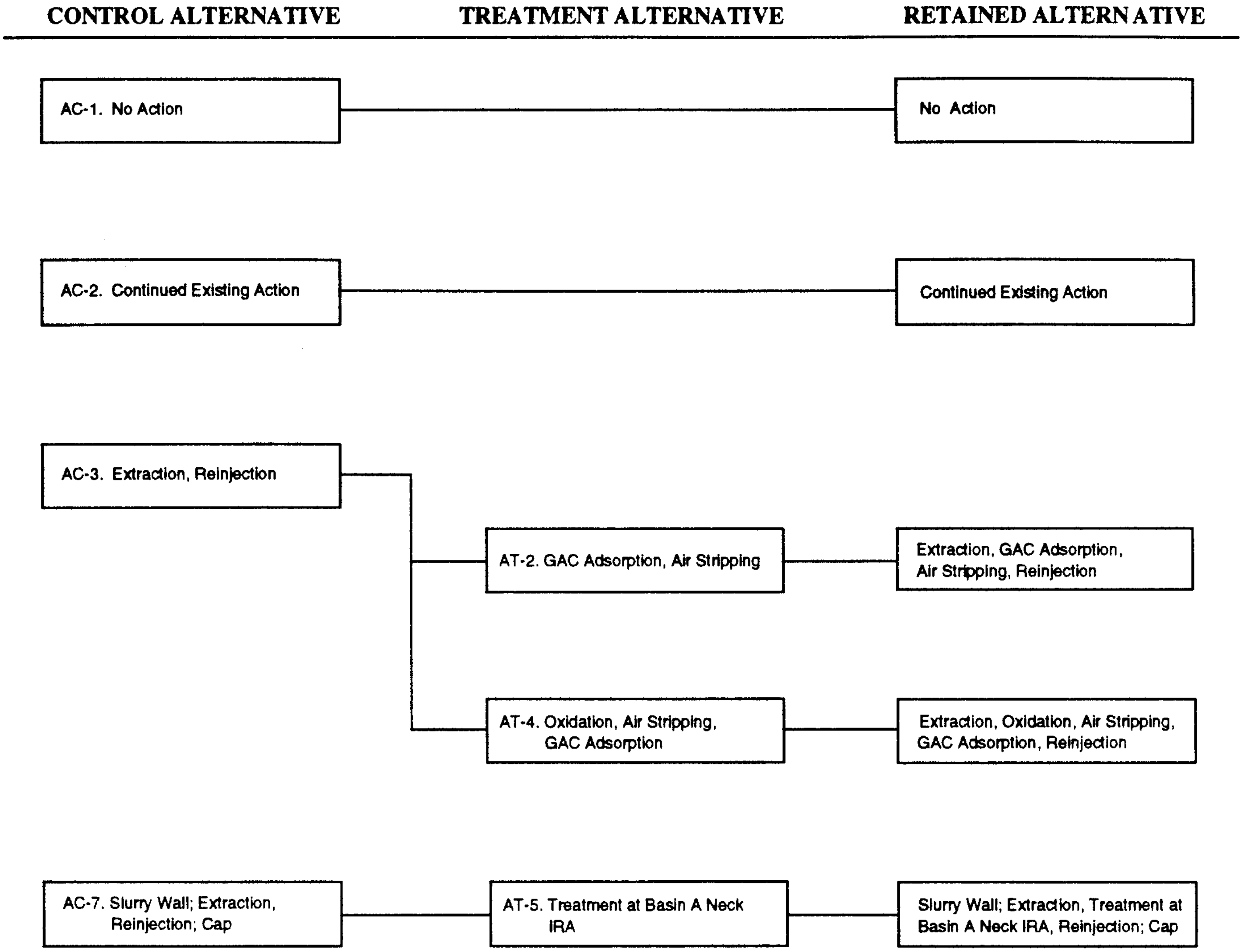
CONTROL ALTERNATIVE	TREATMENT ALTERNATIVE	RETAINED ALTERNATIVE
WC-1. No Action		No Action
WC-2. Continued Existing Action		Continued Existing Action

Figure 1.2-2 Western Plume Group
Alternatives Retained in DSA



NBCS - North Boundary Containment System
GAC - Granular Activated Carbon

Figure 1.2-3 North Boundary Plume Group Alternatives Retained in DSA



GAC - Granular Activated Carbon
IRA - Interim Response Action

Figure 1.2-4 **Basin A Plume Group Alternatives Retained in DSA**

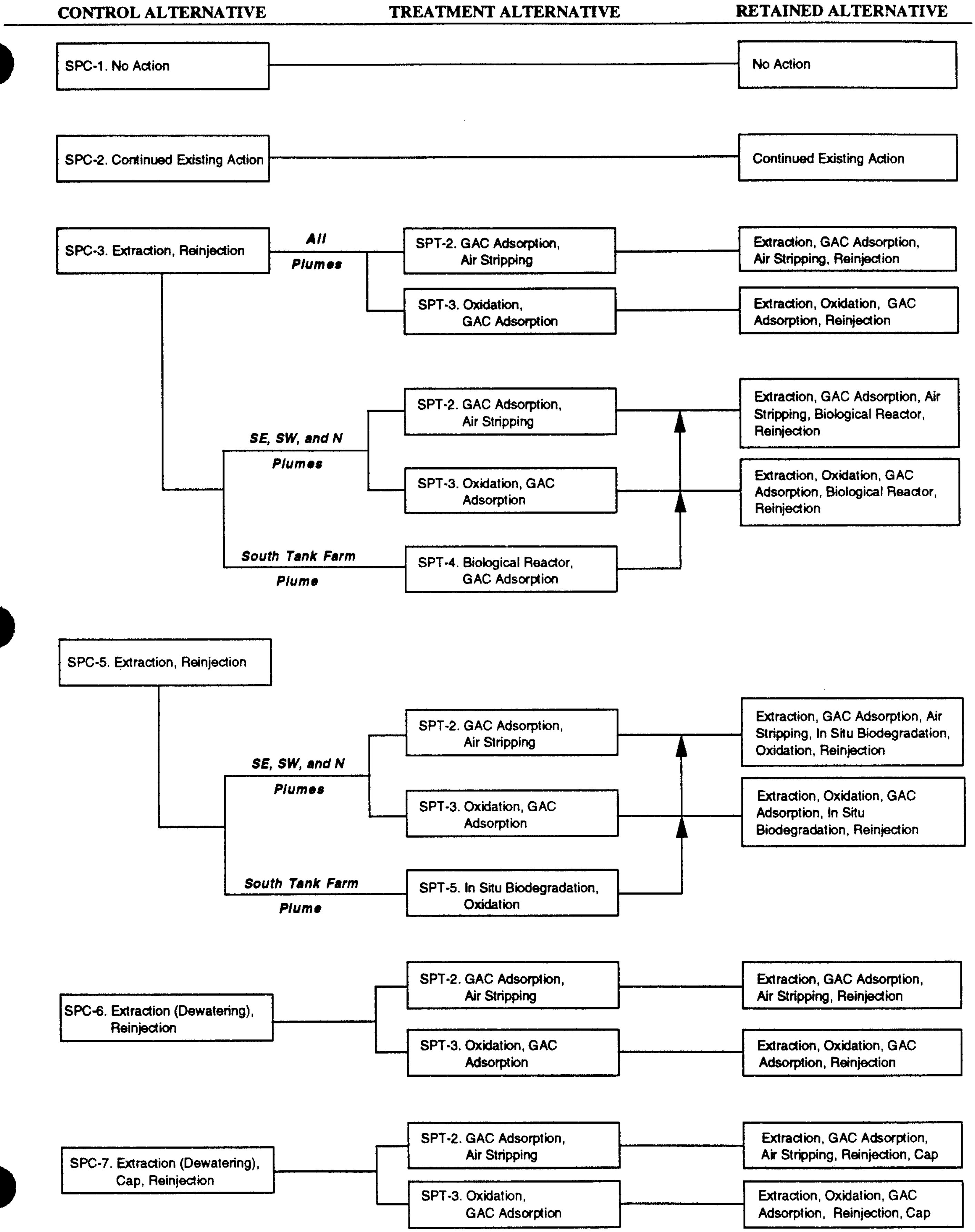


Figure 1.2-5 South Plants Plume Group Alternatives Retained in DSA

2.0 GENERAL DAA METHODOLOGY

2.1 DAA OBJECTIVES

The DAA, the final step in the analysis process that leads to the selection of preferred alternatives, is designed to provide sufficient information to adequately compare alternatives and select the appropriate remedy. The analysis was conducted in accordance with EPA guidance (EPA-OERR 1988), and involved the assessment of each alternative against specific evaluation criteria, followed by a comparative analysis of the alternatives with regard to the criteria. A detailed description of the criteria is provided in the Executive Summary. All of the EPA evaluation criteria, except for state and community acceptance, were considered part of the analysis.

The specific objectives for the Water DAA were to further define each alternative in terms of the following:

- Revised groundwater flow information obtained through modeling and pump tests
- Revised contaminant information based on additional groundwater sampling
- Revised evaluation of plume characteristics
- Revised evaluation of TECs for internal groundwater treatment system alternatives
- Revised process option information based on treatability study results
- Evaluation of alternatives for plume control, mass removal, or dewatering purposes

Similar to the Water DSA, the analysis of groundwater alternatives in the Water DAA was performed separately for each plume group. There is, however, significantly more emphasis placed on the site-wide picture in the Water DAA, including analyzing whether water extracted from the different plume groups may be treated at a common facility (e.g., treat water from South Plants and Basin A at a common facility), or whether existing systems may be used (e.g., treat Basins C and F groundwater at the NBCS or at the Basin A Neck IRA).

2.2 PRELIMINARY REMEDIATION GOALS

The PRGs for water were identified during the Water DSA to address the RAOs established for on-post surface water or groundwater. The remediation goals will be finalized as part of the Record of Decision (ROD). The following PRGs have been established for on-post groundwater:

- Ensure that the boundary containment and treatment systems protect groundwater quality off post by treating groundwater flowing off RMA to the levels listed in Table 2.2-1.

- Develop on-post groundwater extraction/treatment alternatives that enhance or improve the performance of the boundary control systems, achieve significant mass removal of contaminants, or control plume source areas. These alternatives may reduce the duration and cost of the operation of the boundary systems, resulting in a reduction of overall groundwater extraction/treatment costs.

Table 2.2-1 lists the specific PRG levels. These levels represent the values established for off-post groundwater in the off-post FS (HLA 1992b). In addition, primary drinking water standards for inorganics have to be met at the RMA boundary. These values, which were established using applicable or relevant and appropriate requirements (ARARs) and health-based criteria, must be achieved at the RMA boundary.

2.3 TARGET EFFLUENT CONCENTRATIONS

Based on the DSA dispute resolution, TECs will be established for reinjection of water treated at each of the proposed on-post treatment systems. TECs will be developed for each system based on the control/treatment objectives of that system, and will be included as enforceable remediation levels in the Proposed Plan and the ROD.

The on-post treatment systems considered in this report are for treatment of Basin A and South Plants groundwater. Because of the similar contaminant compositions and the potential for utilizing the same treatment systems combined with the proposed common reinjection system, the same TEC values were selected for both plume groups. The TECs selected for these on-post systems are twice the drinking water standards, twice the off-post PRGs, or twice the risk-based criteria identified. Most inorganics, including fluoride, nitrate/nitrite, and cyanide, are not

considered for on-post treatment, but must meet primary drinking water standards at the boundary. Table 1.3-3 lists the TEC values for Basin A and South Plants groundwater.

It should be noted that the established TECs do not apply to the in situ treatment alternative for the South Tank Farm Plume. The aquifer will, in this case, be remediated to the levels that can be achieved through recirculation of water and injection of nutrients during the time period selected for mass reduction.

2.4 MEDIA INTERACTIONS

Interactions between the soil, structures, and water media were evaluated in this document to ensure that compatible alternatives are selected for the different media. Since the soils medium was selected as the primary focus for the purpose of alternative development, the selected alternatives for groundwater must be compatible with the selected soil alternatives.

Remedial actions for soils impact water alternatives in many ways. These interactions, described in more detail in Section 2.1 of the Soils DAA, Volume I, include the following:

- Impact of soils alternatives that do not provide source control and that may adversely impact surface water quality through leachate and particle transport
- Impact of soils alternatives that do not provide source control and that may adversely impact groundwater quality through leachate migration
- Impact of source control alternatives for soils on on-post surface water and groundwater quality
- Impact of source control alternatives for soils on existing boundary groundwater containment systems
- Impact of source control alternatives on proposed groundwater dewatering, mass removal, or plume control alternatives
- Impact of contaminated water, generated through dewatering activities for soils excavation alternatives, on existing or proposed water treatment systems

- Impact of contaminated liquids, generated by soils treatment processes, on existing or proposed water treatment systems
- Impact of groundwater alternative implementation on soils alternatives

Implementation of soils remedial alternatives may also impact groundwater in terms of timing, i.e., soils remedial alternatives may have to be completed prior to initiating groundwater alternatives in the same area. This phased approach was addressed throughout the DAA. For example, the alternatives developed for the South Plants Plume Group involve extraction/treatment of the South Tank Farm Plume separately during soils and structures remedial alternatives.

2.5 THE FEASIBILITY STUDY ANALYSIS PROCESS

2.5.1 Detailed Analysis

A detailed analysis is conducted for each alternative retained in the DSA. The purpose of the detailed analysis is to determine how well each alternative satisfies the DAA evaluation criteria (EPA-OERR 1988). As described in the Executive Summary, the DAA focuses on the seven screening criteria (the two criteria that were not included in this analysis, but will be addressed in the ROD, are state acceptance and community acceptance).

2.5.2 Comparative Analysis

The comparative analysis uses the same criteria as the detailed analysis, but involves a comparison of all the retained alternatives against each criterion. The comparative analysis of the alternatives developed for the water medium was completed on a plume-group-specific basis, i.e., by comparing all of the alternatives within one plume group against each criterion.

2.5.3 Selection of Preferred Alternatives

The selection of preferred alternatives involves comparing the performance of each alternative relative to the seven DAA evaluation criteria. In the Water DAA, a preferred alternative was selected for each plume group.

Table 2.2-1 Preliminary Remediation Goals (PRGs) for Groundwater at the Boundary of Rocky Mountain Arsenal[1] Page 1 of 2

Chemical Group/Compound	Preliminary Remediation Goals (µg/l)
Volatile Halogenated Organics (VHOs)	
1,2-Dichloroethane	1.1
Carbon tetrachloride	0.99
Chlorobenzene	25
Chloroform	15
Tetrachloroethylene	5
Trichloroethylene	0.76
Volatile Hydrocarbon Compounds (VHCs)	
Dicyclopentadiene	46
Volatile Aromatic Organics (VAOs)	
Benzene	1.05
Ethylbenzene	200
Xylenes	1000
Toluene	1000
Organosulfur Compounds; Mustard Agent Related (OSCMs)	
1,4-Oxathiane	160
Dithiane	18
Organosulfur Compounds; Herbicide Related (OSCHs)	
Chlorophenylmethyl sulfide	30
Chlorophenylmethyl sulfone	36
Chlorophenylmethyl sulfoxide	36
Organophosphorus Compounds; Isopropylmethyl Phosphonofluoridate (GB) Agent Related (OPHGBs)	
Diisopropylmethyl phosphonate (DIMP)	600
Organophosphorus Compounds; Pesticide Related (OPHPs)	
Atrazine	4.03
Malathion	100

µg/l Micrograms per Liter

Source: Off-Post Operable Unit Endangerment Assessment/Feasibility Study, Harding Lawson Associates, March 1992 (RIC92094R02)

Table 2.2-1 Preliminary Remediation Goals (PRGs) for Groundwater at the Boundary of Rocky Mountain Arsenal[1] Page 2 of 2

Chemical Group/Compound	Preliminary Remediation Goals (µg/l)
Semivolatile Halogenated Organics (SHOs)	
1,3-Dichlorobenzene	6.5
Hexachlorocyclopentadiene	0.23
Dibromochloropropane (DBCP)	0.195
Organochlorine Pesticides (OCPs)	
Aldrin	0.05
Chlordane	0.095
Dichlorodiphenylethane (DDE)	0.054
Dichlorodiphenyltrichloroethane (DDT)	0.049
Dieldrin	0.05
Endrin	0.2
Isodrin	0.06
Arsenic	2.35
Inductively Coupled Plasma (ICP) Metals	
Manganese	200

µg/l Micrograms per Liter

Source: Off-Post Operable Unit Endangerment Assessment/Feasibility Study, Harding Lawson Associates, March 1992 (RIC92094R02)

3.0 GROUNDWATER CONTROL AND TREATMENT METHODOLOGY

3.1 CHARACTERISTICS OF GROUNDWATER PLUMES

This section describes the plume group configurations and identifies major contaminants for each group. The groundwater quality data discussed in this report are generally analyzed for only the central, most-contaminated portions of a plume (i.e., the areas immediately upgradient of proposed remedial alternatives). The summary of chemical data does not include an evaluation of all chemical analyses for the entire plume area. Appendix B of the Water DSA Volume I summarizes the overall water quality for each plume group.

During the Water DSA, a total of 15 contaminated groundwater plumes were identified and then combined into the five following plume groups: Northwest Boundary, Western, North Boundary, Basin A, and South Plants (Table 3.1-1 and Figure 3.1-1). The primary criteria used for defining plume groups was the proximity of the plumes to one another and the location of the plumes with respect to existing or planned groundwater control and treatment systems developed under IRAs and the boundary systems. During the DAA, new plume maps were completed to include recent data that became available after issuance of the DSA. Plume maps for the DAA were generated by summing the geometric means for each target organic analyte over the time period 1989–92 for each unconfined well. These values were hand-contoured using knowledge of several hydrogeologic factors such as current and historic groundwater flow directions and rates, aquifer characteristics, modeling results, bedrock surface configuration, and historic plume geometries. Target organic analytes that were included in the plume maps are listed in Table 3.1-2.

3.1.1 Northwest Boundary Plume Group

The Northwest Boundary Plume Group includes the Basin A Neck Plume and the Sand Creek Lateral Plumes. Contaminated groundwater flow occurs primarily within small alluvial-filled paleochannels near the plume sources and within thick, saturated terrace deposits along the northwest RMA boundary. The existing Northwest Boundary Containment System (NWBCS) was installed to intercept and treat these plumes on post (Figure 3.1-1). The Basin A Neck Plume extends from Basin A in Section 36 to the northwest boundary of RMA. The Sand Creek

Lateral Plumes appear to originate in the vicinity of the Sand Creek Lateral in the western portion of Section 35 and merge with the Basin A Neck Plume. During the Water DSA, these plumes were eliminated from further consideration for on-post treatment because contaminants were present at low concentrations and the NWBCS already provided treatment for these plumes. Therefore, no additional statistical evaluation of plume concentrations was conducted for the Water DAA.

3.1.2 Western Plume Group

The Western, Motor Pool, and Railyard Plumes are collectively defined as the Western Plume Group (Figure 3.1-1). The sources of the Motor Pool and Railyard Plumes are located on post; the Western Plume, however, originates off post and extends on post. The Motor Pool and Railyard Plumes, and those portions of the Western Plume that extend off post, are extracted and treated by the Irondale Containment System (ICS) or the South Adams County Water and Sanitation District (SACWSD) water supply wells and water treatment plant. The plumes occur primarily within thick alluvial terrace deposits. During the Water DSA, this plume group was eliminated from further consideration for on-post treatment because contaminant concentrations near the RMA boundary were low and the plumes were adequately controlled by the existing systems. Accordingly, no additional statistical evaluation was conducted.

3.1.3 North Boundary Plume Group

The North Boundary Plume Group includes the Basins C and F Plume and the North Plants Plume (Figure 3.1-1). The NBCS extracts and treats these plumes as they approach the northern boundary of RMA. The Basins C and F Plume flows primarily within alluvial-filled paleochannels and to a lesser extent through weathered bedrock. The North Plants Plume flows primarily within sandy alluvial material. Water-quality data was reviewed for the portions of these plumes that would be extracted by proposed groundwater control and treatment systems. Within these areas, chloroform is the only contaminant detected at a mean concentration above its PEC in the Basins C and F Plume, and no contaminants were detected in the North Plants Plume at mean concentrations exceeding PECs.

3.1.4 Basin A Plume Group

The Basin A Plume Group includes the Basin A Plume, the South Plants North Plume, and the Section 36 Bedrock Ridge Plumes (Figure 3.1-1). Contaminated groundwater flow in the South Plants North and Basin A Plumes occurs principally within saturated alluvium, with lesser flow through the underlying weathered bedrock. However, in the Section 36 Bedrock Ridge area, the water table generally lies below the alluvium and groundwater flows predominantly within weathered bedrock. Water-quality data was reviewed for the portions of these plumes that would be extracted by proposed groundwater control and treatment systems. Contaminants detected at mean concentrations exceeding the respective PECs in the total extracted stream from these portions of the Basin A Plume Group include chloroform, methylene chloride, dibromochloropropane (DBCP), tetrachloroethylene, benzene, aldrin, and chlordane.

3.1.5 South Plants Plume Group

The South Plants Plume Group includes the South Plants Southeast, Southwest, North Source, and the South Tank Farm Plumes. The South Plants North Plume was split into the North Source and the South Plants North Plume as part of the Basin A Plume Group during the Water DAA to further describe the South Plants area. Groundwater in these plumes flows principally within the weathered, upper portion of the Denver Formation. Small portions of the South Plants North Source and South Plants Southeast Plumes also flow within areas of thin, saturated alluvium. The South Plants Southwest Plume did not have any PEC exceedances and, therefore, was not included in overall plume group evaluations. Contaminants detected at mean concentrations exceeding the respective PECs in the combined stream from these portions of the South Plants Plume Group include chloroform, benzene, and DBCP. Water-quality data was reviewed for the remaining portions of the South Plants Plume Group that would be extracted by proposed groundwater control and treatment systems.

3.2 ESTIMATION OF CONCENTRATION AND MASS OF CONTAMINANTS IN GROUNDWATER

3.2.1 Extraction System Design Concentrations

A two-step approach was used to estimate the chemical concentration of groundwater extracted by control/treatment alternatives. The first step of the approach provided an areal hydrological, and time-based rationale for selecting which upgradient monitoring points (wells) to include in calculations of extracted water chemistry. In the second step, the mean concentration of each chemical constituent was estimated by the TSGM method.

Only those monitoring wells that fell inside a stream-tube (i.e., capture-zone) segment that originated at the location of the extraction system were selected for use in the calculations. For interceptor systems, it was assumed that the stream tube extends upgradient a distance equivalent to 5 years of travel time under current flow conditions; for mass reduction system calculations, it was assumed that the stream tube extends a distance equivalent to 10 years of travel time by a target contaminant under induced-flow conditions.

Existing water-level contours and flow-net concepts were used to estimate and delineate on a map the width of the stream tube extending upgradient from the proposed groundwater extraction system. The representative average linear velocity of groundwater was calculated using Darcy's law (Freeze and Cherry 1979) and best estimates of local hydraulic gradient, hydraulic conductivity, and effective porosity. The distance traveled by groundwater at this velocity during a 5-year time period was calculated and the stream tube was extended that distance upgradient from the proposed extraction system location. For a given contaminant of interest, the apparent retarded velocity of the dissolved contaminant was calculated and used to estimate the distance traveled over a 10-year period for mass reduction calculations. Only data from wells falling within the defined stream-tube segment were used in the statistical calculation of the mean contaminant concentration.

The retarded velocity of selected contaminants were calculated by the retardation equation (Freeze and Cherry 1979) using soil and chemical parameters taken from the on-post Integrated Endangerment Assessment/Risk Characterization (EBASCO 1993).

3.2.2 TWO-STEP GEOMETRIC MEAN CONCENTRATIONS

The TSGM of a compound within stream-tube segments was computed as follows. In the first step, the geometric mean of all samples collected throughout a given time period for each individual well was estimated as:

$$GM_1 = \sqrt[n]{(V_1)(V_2)\ldots(V_n)}$$

where:

GM_1 =	geometric mean of analytes in a given well throughout sampling period t
n =	number of samples collected and analyzed
$V_1 \cdots V_2$	individual detected contaminant concentration values. If a value was below the Certified Reporting Limit (CRL), a value was calculated using the Robust Method (Helsel 1990). If a given well had less than a 50-percent detection ratio (number of detections to number of total samples), one-half of the CRL as used. One-half of the CRL was also used if there were less than three total detections.

In the second step, the geometric mean concentration between all wells in the stream tube was calculated. This required estimating the overall geometric mean for the stream tube (GM_s) for all wells (m) located within the stream tube, based on the GM_1 for each of these wells as follows:

$$GM_s = \sqrt[m]{(GM_1)(GM_2)...(GM_{tm})}$$

where:

GM_s = geometric mean of the GM values for all wells "1" through "m" located within the stream tube

m = number of wells in the stream tube

$GM_1...GM_m$ = individual values of GM, for all wells numbered "1" through "m"

The TSGM method was used to characterize a plume's overall water quality and to estimate influent concentrations because it is resistant to outliers and anomalies, and thus provides a representative estimate of the mean concentration. The wells that were used to estimate influent concentrations for the system considered in the DAA are listed in Table 3.2-1.

3.2.3 Mass Reduction Estimates

For those alternatives in which mass reduction is included as the main objective of the alternative or as a preliminary phase of remediation, estimates were made of the length of time required to remove a substantial mass of dissolved contaminant from the most highly contaminated portion of each plume. The estimates were then used as the basis of the duration of the mass-reduction phase. For design purposes, the removal of 25 percent or more of the total dissolved mass within a plume was considered as a significant decrease in contaminant mass.

The duration of extraction is highly variable depending on local hydrogeologic conditions and on contaminant chemical characteristics. The relative velocities of contaminants considered, when compared to the average linear velocity of groundwater for the same hydrogeologic conditions, range from 0.22 for chlordane to 0.97 for methylene chloride. The commonly occurring compounds benzene, chloroform, and chlorobenzene have relative velocities of 0.85, 0.93 and 0.82, respectively. For mass reduction, it was assumed that a minimum of one pore

volume of contaminated groundwater is removed from the targeted, highly contaminated portion of the aquifer and that desorption of contaminants from aquifer material is not considered. In most alternatives, more than one pore volume of groundwater is flushed through the more permeable aquifer materials in order to achieve the one pore volume goal in low-permeability material due to the heterogeneity of the aquifer.

The period of time required for operation of the mass reduction systems varies widely from plume to plume, ranging from approximately 1.5 years for mobile compounds in permeable aquifer materials to more than 10 years for low relative velocity (retarded) compounds in low-permeability materials. The actual period of operation will be determined by the design of the final well configuration in the design phase of the remedy. Another factor that can impact the period of operation is the rate at which control of the soil source areas is accomplished. For these reasons, the duration of mass reduction was rounded up to a 10-year period both to simplify the comparison of alternatives and to allow water produced from the systems to be treated at a common treatment facility over a consistent time period.

3.3 THE USE OF GROUNDWATER MODELING IN THE EVALUATION OF REMEDIAL ALTERNATIVES

The South Plants/Basin A numerical groundwater flow model, which was developed as part of the DAA (EBASCO 1993), was an important tool during the evaluation of groundwater remedial alternatives, serving to simulate the hydrogeologic flow conditions that may result from the application of each groundwater remedial alternative. A numerical groundwater flow model was selected for use because it is particularly helpful where hydrogeologic conditions are complex due to heterogeneity of geologic materials or restrictive boundary conditions. In addition, a numerical model provides a robust means of representing many groundwater extraction/treatment hydraulic components such as wells, trenches, caps, and barriers. The model, therefore, provides a basis for comparison of remedial alternatives within a modeled area.

The following general groundwater modeling objectives were identified for modeling applications during the DAA:

- Help evaluate the effectiveness of various groundwater extraction and injection (control) alternatives and their potential effects on boundary containment systems
- Help evaluate of the range of time that may be required to operate proposed on-post remedial systems
- Help evaluate the potential impacts of groundwater control alternatives on the hydrogeologic system and on groundwater management practices
- Develop a better understanding of groundwater flow mechanisms and pathways at RMA

In addition to these general objectives, the South Plants/Basin A flow model was designed to meet specific modeling objectives. The objectives for the model are discussed in detail, along with details of the hydrogeologic conceptual model, specific modeling objectives, limitations of use, code selection, and other aspects of the modeling process, in the South Plants/Basin A groundwater modeling report (EBASCO 1993).

The level of modeling sophistication that was applied for a given remedial alternative depended on local hydrogeologic conditions and the complexity of the alternatives considered for use in that area. In general, numerical models are more applicable and robust in areas where the hydrogeology is complex, the alternatives have several components, or the remedial alternatives impact groundwater conditions at another extraction/treatment location. The decision as to which modeling method to employ also considered constraints on the hydrogeologic data available, specific project and modeling goals, and schedule.

The following subsections summarize the modeling approach that was taken for each groundwater plume group.

Northwest Boundary Plume Group

No retained alternatives for this plume group require the application of groundwater flow models.

Western Plume Group

No retained alternatives for this plume group require the application of groundwater flow models.

North Boundary Plume Group

Improved estimates of the groundwater flux through the area north of Basin F were made by the application of Darcy's law using recent estimates of the water table elevation and hydraulic gradient.

No groundwater remedial actions were retained for the North Plants Plume due to low groundwater contaminant levels (below PECs) in that area. Therefore, no modeling was required for the North Plants area.

South Plants and Basin A Plume Groups

The remedial alternatives for the Basin A and South Plants Plume Groups were evaluated by use of a single three-dimensional (3-D) multilayer groundwater flow model. The primary reason for representing both areas in one model was the expected interaction between groundwater remedial alternatives for the two plume groups. For example, the groundwater mound dewatering alternatives evaluated for the South Plants area have a direct impact on aquifer conditions in Basin A and have significant impacts on alternatives developed for that area. In addition, the model was used to consider interaction between alternatives developed for the soils and water media.

Particle tracking was used to evaluate the capture effectiveness of groundwater control alternatives and to define groundwater flow paths. Analytical solutions were used to evaluate contaminant migration rates in a few specific applications. No contaminant-transport capability was incorporated into the numerical groundwater flow models.

The flow model used for simulations was the U.S. Geological Survey (USGS) Modular Finite Difference Groundwater Flow 3-D Model, MODFLOW (McDonald and Harbaugh 1988).

MODFLOW is a widely used, finite-difference model that has been applied to many complex flow problems. A particle-tracking model, PATH3D (Zheng 1992) was coupled with MODFLOW to compute and display flow path lines used in the development of flow nets. PATH3D uses a semianalytical algorithm to describe the flow path within a grid cell and particle movement along the flow path.

The model was designed and calibrated against observed hydrogeologic information by matching the model-calculated hydraulic heads with observed water levels at well locations through adjustments of hydrogeologic parameters. Water-level elevations for the period summer 1990 to spring 1992 were used as a basis for calibration and were compared to the results of the model simulations. Over most of the study area, the match of simulated to observed water levels was excellent: less than 1-foot (ft) difference for 90 percent of the measuring points. This indicates a good match to the observed data and a good calibration. Based on the favorable results from model setup and calibration, the model was considered to be an acceptable representation of the hydrogeologic system in the study area. The full details of model setup, model grid selection, aquifer properties, calibration, and sensitivity analyses are presented in the South Plants/Basin A groundwater modeling report (EBASCO 1993) along with selected final simulation results.

After adequate calibration was achieved, simulations were run to assess the performance of various groundwater extraction/treatment system designs for a variety of different mass reduction, interception, and other control alternatives. Design runs involved varying the location and pumping rates of the extraction wells and determining the resulting radius of influence for each well and the effect of the overall system on the capture of the contaminated plume. This was accomplished by combining the particle-tracking capability of PATH3D with the hydraulic head results from MODFLOW. Particles were input into the groundwater model along the targeted portion of the contaminant plume. The movement of the particles was then tracked and the effectiveness of capture for alternative design scenarios compared. In this way, the extent of capture was assessed.

In all of the modeled alternatives, it was assumed that the extracted water is treated at an on-post treatment plant and that the treated water is then recharged into the aquifer to maintain the water balance. In the case of the in situ biodegradation alternative for the South Tank Farm Plume (Alternative SPC-5), most of the groundwater treatment actually occurs in the subsurface, so the model simulates the hydraulic control of the injection well and extraction well system.

Table 3.1-1 Water Medium Plume Groups

Plume Group	Components
Northwest Boundary	Basin A Neck Plume Sand Creek Lateral Plumes[1]
Western	Western Plume Motor Pool Plume Railyard Plume
North Boundary	Basins C and F Plume North Plants Plume
Basin A	Basin A Plume Section 36 Bedrock Ridge Plumes[1] South Plants North Plume[2]
South Plants	South Tank Farm Plume South Plants Southwest Plume South Plants Southeast Plume South Plants North Source Plume[2]

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[1] The Sand Creek Lateral Plumes and the Section 36 Bedrock Ridge Plumes each consist of two separate plumes.

[2] The South Plants North Source Plume originates in the South Plants area and then migrates northward into the Basin A area. The portion of the plume that lies within the South Plants area (south of December Seventh Avenue) is called the South Plants North Source Plume and is dealt with as a part of the South Plants Plume Group alternatives. The portion of the plume that lies within the Basin A area is named the South Plants North Plume and is addressed as part of the Basin A Plume Group.

Table 3.1-2 List of Target Organic Analytes

1,1,1-Trichloroethane
1,1,2-Trichloroethane
1,1-Dichloroethylene/1,1-Dichloroethene
1,1-Dichloroethane
1,2-Dichloroethane-D4
1,2-Dichloroethenes/1,2-Dichloroethylenes
(*cis* and *trans* isomers)
1,2-Dichloroethane
1, 2-Dichloropropane
1,3-Dichlorobenzene
1,3-Dimethylbenzene/m-Xylene
1,4-Dichlorobenzene
Acetone
Aldrin
Atrazine
Bicyclo[2,2,1]hepta-2,5-diene
Bromodichloromethane
Benzothiazole
Vinyl chloride
Benzene
Trichlorofluoromethane
Carbon tetrachloride
Methylene chloride
Chloromethane
Chloroform
Hexachlorocyclopentadiene
Chlorobenzene
Chlordane
p-Chlorophenylmethyl sulfide (CPMS)
p-Chlorophenylmethyl sulfoxide (CPMSO$_2$
p-Chlorophenylmethyl sulfone (CPMSO)
Dibromochloropropane (DBCP)
Dichlorobenzene
Dicyclopentadiene (DCPD)
Vapona
Diisopropyl methylphosphonate (DIMP)
Dithiane
Dieldrin
Dimethyl disulfide
Dimethyl methylphosphonate (DMMP)
Endrin
Ethylbenzene
Hexachlorobutadiene
Isopropyl methylphosphonic acid/ Isopropyl methylphosphonate (IMPA)
Isodrin
Toluene
Methylisobutyl ketone
Malathion
Methylphosphonic acid
N-Nitrosodimethylamine (NNDMEA)
N-Nitrosodi-N-propylamine (NNDNPA)
1,4-Oxathiane
2,2-Bis (p-chlorophenyl)-1,1-dichloroethene (PPDDE)
2,2-Bis (p-chlorophenyl)-1,1,1-trichloroethane (PPDDT)
Parathion
Supona
1,1,2,2-Tetrachloroethane
Tetrachloroethylene
Thiodiglycol
Trichloroethylene
Xylenes

Table 3.2-1 Wells Used to Calculate TSGM Values

Plume	Well Number
Basins C and F Plume	23049, 23237, 23530, 26041, 26133, 26148, 26149, 26157, 26161, 26162, 26163, 26166, 26171, 26173
Section 36 Bedrock Ridge North Plume	36184, 36191, 36192
Section 36 Bedrock Ridge South Plume	36185, 36199, 36200
Basin A Plume (System 1*)	36054, 36055, 36056, 36058, 36076, 36109, 36167, 36168, 36193, 36194, 36511, 36512, 36603
Basin A Plume (System 2*)	36080, 36084, 36089, 36187, 36188, 36189, 36190
South Plants North Plume	01078, 01083, 01300, 01503, 01504, 01507, 01513, 01514, 01515, 01524, 01525, 01572, 01573, 36054, 36058, 36168, 36193
South Plants Southeast Plume	01061, 01517, 02005
South Tank Farm Plume	01014, 01088, 01089, 01095, 01096, 01097, 01102, 01533, 01534, 01535, 01539, 01540, 01541, 01552, 01554, 01559, 01565, 02561, 02562, 02575, 02582, 02583, 02584
South Plants Dewatering Block 1	02003, 02053, 02594
South Plants Dewatering Block 2	01020, 01083, 01503, 01504, 01507, 01513, 01524, 01525, 01572, 01573
South Plants Dewatering Block 3	01078, 01300, 01511, 01514, 01515, 01516
South Plants Dewatering Block 4	01061, 01101, 01104, 01109, 01517
South Plants Dewatering Block 5	01088, 01095, 01096, 01097, 01100, 01102, 01533, 01534, 01535, 01565
South Plants Dewatering Block 6	01068, 01084, 01522, 02058, 02572, 02581
South Plants Dewatering Block 7	01007, 02005, 02007, 02061, 02064, 02065, 02545

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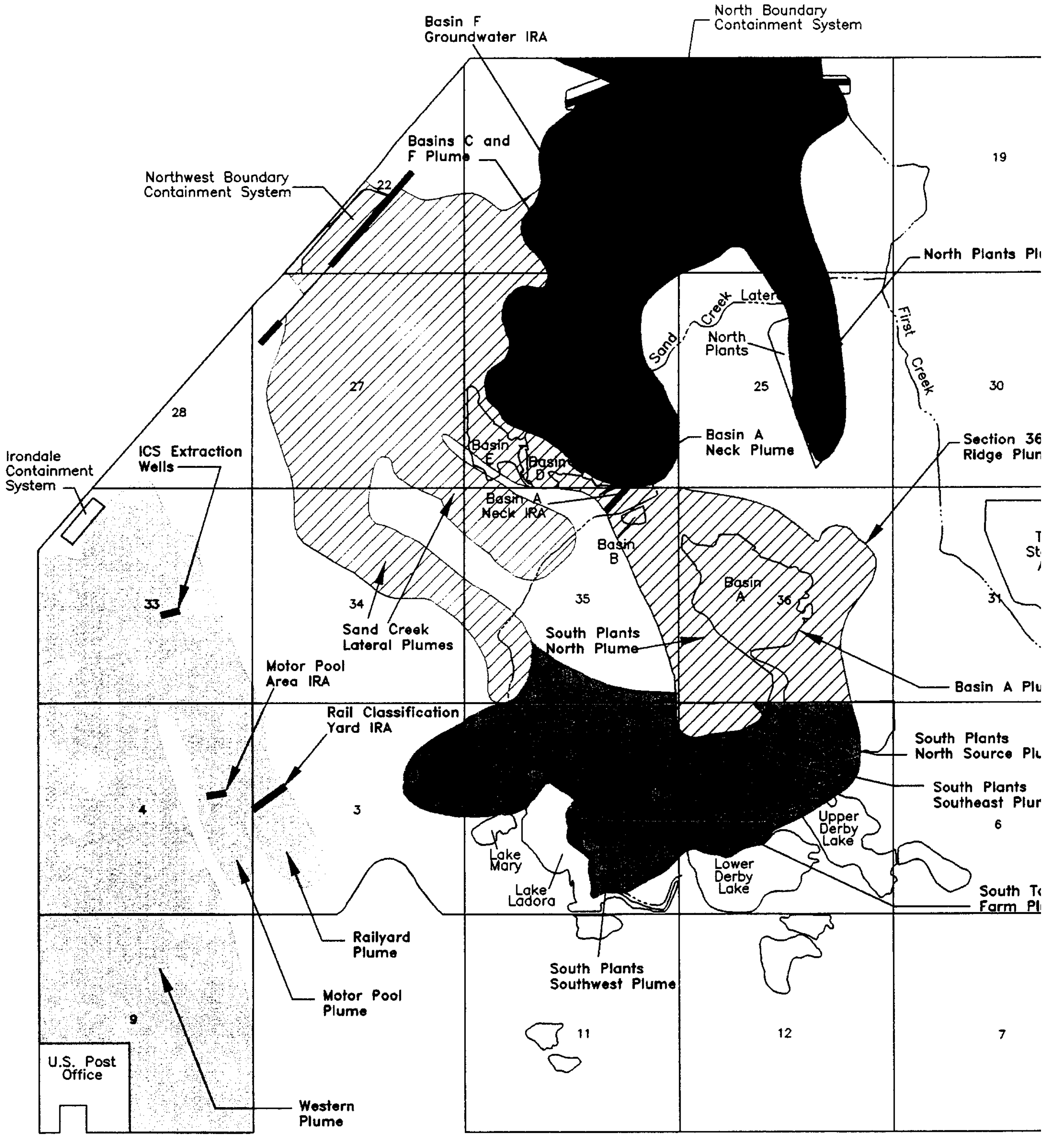
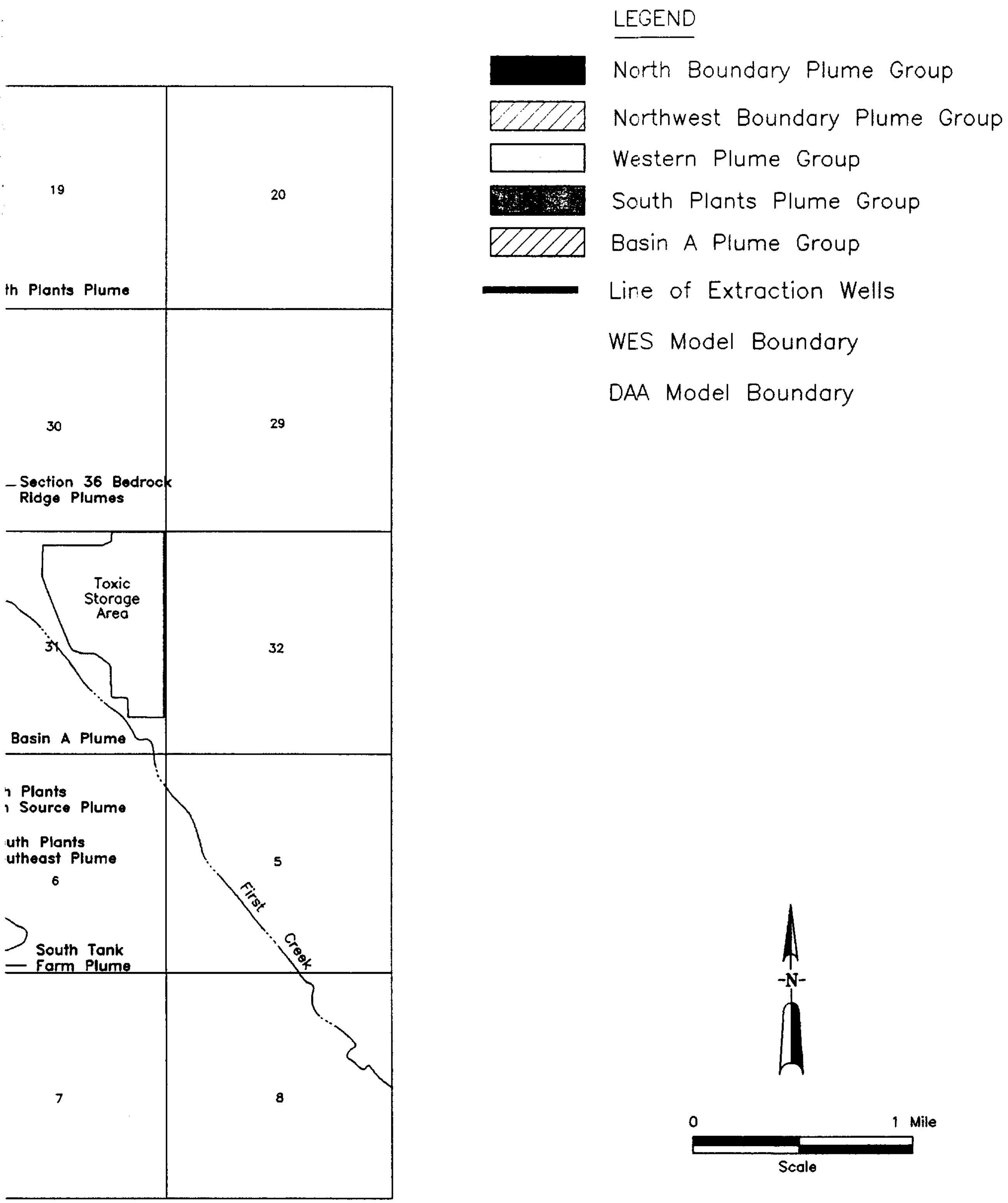
* System 1 and System 2 denote proposed extraction systems in the Basin A Plume.



Basin F
Groundwater IRA
North Boundary
Containment System
Basins C and
F Plume
Northwest Boundary
Containment System
22
19
North Plants Pl
Sand Creek Later
North
Plants
First Creek
27
28
25
30
Irondale
Containment
System
ICS Extraction
Wells
Basin
E
Basin
D
Basin A
Neck Plume
Section 36
Ridge Plun
Basin A
Neck IRA
Basin
B
Basin
A
33
34
35
36
31
T
St
Sand Creek
Lateral Plumes
South Plants
North Plume
Basin A Plu
Motor Pool
Area IRA
Rail Classification
Yard IRA
South Plants
North Source Plu
South Plants
Southeast Plur
4
3
6
Upper
Derby
Lake
Lake
Mary
Lake
Ladora
Lower
Derby
Lake
South To
Farm Pl
Railyard
Plume
South Plants
Southwest Plume
Motor Pool
Plume
9
11
12
7
U.S. Post
Office
Western
Plume



SOURCE: Water DSA Plume Map

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 3.1-1

Historical Total Organic Plumes for Unconfined Flow System (from DSA)

Prepared by:
EBASCO SERVICES INCORPORATED

4.0 NORTHWEST BOUNDARY PLUME GROUP

Two alternatives, NWC-1, No Action, and NWC-2, Continued Existing Action, were retained for further analysis in the Water DAA for the Northwest Boundary Plume Group. This plume includes the Basin A Neck Plume and the Sand Creek Lateral Plumes. Currently there is one treatment system, the NWBCS, treating the water in the Northwest Boundary Plume Group.

The NWBCS is a pump-and-treat system at the RMA boundary that prevents off-post migration of the contaminants in the Northwest Boundary Plume Group. It consists of a series of extraction wells, three GAC adsorbers (two operated in series and one backup), and a reinjection system (a series of reinjection wells). A slurry wall was installed between part of the extraction and reinjection well lines to reduce recirculation of the reinjected water. Section 4.2.1 provides a more detailed description of the NWBCS.

The following sections provide detailed descriptions and analyses for each of the two alternatives retained from the Water DSA for the Northwest Boundary Plume Group. Table 4.0-1 presents a summary of the comparative analyses. Only two alternatives were retained in the Water DSA due to low contaminant concentrations. In the DAA, plume characteristics were again compared to the PECs (Table 1.3-1) and were found not to warrant additional alternative development and analysis.

4.1 ALTERNATIVE NWC-1: NO ACTION

4.1.1 Description of Alternative

Alternative NWC-1 for the Northwest Boundary Plume Group involves discontinuing all current and planned activities. Under this alternative, operation at the NWBCS is discontinued and none of the planned modifications are initiated. The slurry wall is breached by approximately four permeable trenches so that the aquifer returns to its natural state rather than building up behind the slurry wall. Dismantling or future use of remedial action support structures, such as the northwest boundary treatment buildings, are included as part of the No Future Use,

Manufacturing History Medium Group in the Structures DAA. Groundwater is monitored annually using ten existing wells. Figure 4.1-1 presents the No Action alternative.

4.1.2 Analysis of Alternative

4.1.2.1 Overall Protection of Human Health and the Environment

This alternative does not provide protection to human health and the environment. Under this alternative, any existing treatment facilities or IRAs are discontinued. Once the NWBCS is shut down, contaminated groundwater is free to migrate off post.

4.1.2.2 Compliance with ARARs

Action-specific ARARs listed in Technology Description Volume, Appendix A, are not relevant if Alternative NWC-1 is chosen. Because contaminated groundwater is not extracted and treated at the NWBCS, this remedial alternative does not comply with all potential chemical-specific ARARs, although it does comply with all potential location-specific ARARs listed in Appendix A, Volume I, of the Water DSA.

4.1.2.3 Long-Term Effectiveness and Permanence

Alternative NWC-1 is not effective in reducing the magnitude of residual risks. Since no action is taken toward controlling contamination, this alternative is not effective in the long term, and contaminants are free to migrate off post. Some natural attenuation of untreated water takes place, but is not sufficient to achieve RAOs in 30 years.

4.1.2.4 Reduction of TMV

Alternative NWC-1 does not control or treat contaminants, so the only reduction in contaminant TMV is caused by natural attenuation. Contaminated groundwater is free to migrate off post.

4.1.2.5 Short-Term Effectiveness

Alternative NWC-1 is not effective in the short term. This alternative causes a minimal negative impact to workers because the only action undertaken is breaching the slurry wall. However, contamination currently in the aquifer is not treated and is free to migrate off post.

4.1.2.6 Implementability

This alternative is technically implementable. It would require approximately 1 year to shut down the existing systems and breach the slurry wall. The alternative is not administratively feasible, however, because it allows contaminated water to migrate off post and therefore does not comply with the FFA.

4.1.2.7 Costs

The costs for this alternative include breaching the slurry wall, shutting down the NWBCS, and continued monitoring. The capital cost for this alternative is $48,000. The annual operations and maintenance (O&M) costs are $37,500, and the 30-year present worth cost is $647,000. A summary of these costs is presented in Appendix A, Table A1-1.

4.2 ALTERNATIVE NWC-2: CONTINUED EXISTING ACTION

Alternative NWC-2 includes capture and treatment of the groundwater by the NWBCS as it approaches the RMA boundary. The contaminants that exceed PRGs in the Northwest Boundary Plume Group are atrazine, chlordane, and dieldrin. This alternative also includes continued groundwater monitoring and continued compliance with the FFA.

4.2.1 Description of Alternative

The NWBCS is designed to capture and treat organic contaminants, primarily dieldrin, in groundwater approaching the northwest boundary. The NWBCS includes extraction wells, a slurry wall, reinjection (recharge) wells, and a GAC adsorption system. The Short-Term Improvements IRA (Shell 1990a) was initiated to modify the system and to address the movement of low levels of dieldrin off post south of the NWBCS. The Long-Term

Improvements IRA assessment (Woodward-Clyde Consultants 1991) addresses the long-term operation of the NWBCS, including the Short-Term Improvements IRA. It was assumed that under this alternative the present monitoring programs continue. Figure 4.2-1 presents the Continued Existing Action alternative.

4.2.1.1 Extraction/Reinjection

The original slurry wall was installed along the northwest boundary to minimize migration of the contaminated groundwater flowing across that boundary. The wall, constructed of soil/bentonite, originally measured 1,425 ft long by 3 ft wide, and ranged up to 30 ft deep. The slurry wall extended approximately half the length of the extraction/injection system; therefore, a significant volume of treated water that was reinjected recirculated back through the extraction system. Originally, a total of 15 extraction wells were used to remove groundwater and 21 reinjection wells were used for recharge. Five extraction wells were located along the slurry wall and the other ten were installed to the southwest, with no slurry wall between the extraction and reinjection wells.

In October 1990, Phase I of the Short-Term Improvements IRA was completed, extending the slurry wall an additional 665 ft in the northeast direction to intercept groundwater flowing through the alluvial channel to the northeast. The slurry wall extension was keyed a minimum of 10 ft into the existing slurry wall and the extension ranged from 28 to 35 ft deep (PMRMA 1992). Two additional extraction wells, pumping approximately 1 to 2 gallons per minute (gpm) each, were also added along the new extension under Phase I of the Short-Term Improvements IRA. In October 1991 under Phase II of the Short-Term Improvements IRA, three extraction wells were also installed just southwest of the NWBCS, as were four reinjection wells completed to the southeast of the newly installed extraction wells to push groundwater along a small local groundwater divide towards the NWBCS. Currently, the new southwest extension flow rates vary, but the southwest extension is extracting and reinjecting approximately 350 gpm (James 1993). The rest of the NWBCS is extracting and reinjecting approximately 600 gpm for a total system flow of approximately 950 gpm (James 1993). The Long-Term Improvements IRA

includes the Short-Term Improvements IRA as well as monitoring of the entire NWBCS. Seven monitoring wells were installed in March 1992 as part of the Long-Term Improvements IRA and quarterly sampling was conducted from April 1992 to January 1993. The Long-Term Improvements IRA Report is due in June 1993.

Treated water is currently discharged into an effluent sump from which the water is pumped via two 500-gpm pumps through a recharge header pipe to the reinjection (recharge) wells. The system includes two 500-gpm backup pumps on standby. There are 21 recharge wells that range in depth from approximately 40 to 60 ft below the ground surface.

4.2.1.2 Treatment

Groundwater is pumped from the extraction wells to the influent sump adjacent to the treatment building. The influent sump contains four 500-gpm pumps, two of which are currently operating, although this may change (James 1993). Currently, the treatment system consists of three identical GAC vessels, two of which are operated in parallel; the third is used as a backup unit. Each vessel contains 40,000 pounds (lbs) (1,400 cubic feet [ft^3]) of carbon, is operated in an upflow mode, and has a design capacity of 500 gpm and a residence time of 22 minutes. Each of the two on-line carbon vessels is treating approximately 475 gpm of water. Approximately 5,000 lbs of carbon is replaced every quarter (James 1993).

The treatment plant also includes a 30,000-lb fresh-carbon storage tank and a 20,000-lb spent-carbon storage tank. Water is pumped from the feedwater sump through three parallel bag filters (5 micron) to remove suspended solids prior to entering the GAC vessels. The effluents from the vessels pass through three more parallel filters where suspended solids are removed. Overflow and backwash streams are recycled through the carbon units.

4.2.1.3 Sidestreams

The NWBCS generates two sidestreams requiring treatment or disposal, spent carbon and filter solids. The spent carbon in the adsorbers is removed and regenerated at an off-post facility. The filter solids and filter bag materials are drummed and disposed in an off-post landfill that is regulated by the Resource Conservation and Recovery Act (RCRA).

4.2.2 Analysis of Alternative

4.2.2.1 Overall Protection of Human Health and the Environment

Alternative NWC-2 provides protection of human health and the environment. Groundwater is captured and treated to PRGs before it leaves the northwest boundary, which protects the surrounding communities from exposure to contaminants via groundwater. Human health is protected on post by the FFA, which prohibits the use of RMA groundwater as potable water.

4.2.2.2 Compliance with ARARs

The remedial alternative is in compliance with all potential action-specific ARARs listed in Technology Description Volume, Appendix A, including those related to the extraction systems and air emission controls, because it uses an existing system that complies with these ARARs. The existing system also complies with all chemical-specific ARARs (so long as PRGs are achieved at the RMA boundary through continued operation of the NWBCS) and also ensures compliance with all potential location-specific ARARs applicable to groundwater listed in Appendix A, Volume I of the Water DSA.

4.2.2.3 Long-Term Effectiveness and Permanence

There is low residual risk because the contaminants in groundwater are treated to PRGs before the water migrates off post. Alternative NWC-2 provides for adequate controls, but long-term maintenance is required to ensure the reliability of the NWBCS. The treatment system may require longer than 30 years of operation to ensure continued protection of the surrounding community.

4.2.2.4 Reduction of TMV

Treatment at the NWBCS reduces the contaminant TMV in groundwater through GAC adsorption and regeneration of the spent carbon. The NWBCS is currently treating 950 gpm of contaminated groundwater.

4.2.2.5 Short-Term Effectiveness

Alternative NWC-2 provides worker protection under the existing health and safety plan at the NWBCS and under any future plans. The community is protected under this alternative because groundwater treatment at the NWBCS minimizes the potential for off-post migration of contaminants. The Long-Term Improvements IRA monitoring program report (June 1993) will generate additional information on the effectiveness of the NWBCS.

4.2.2.6 Implementability

This alternative is technically and administratively implementable. The control/treatment systems are currently operating, making this alternative readily implementable.

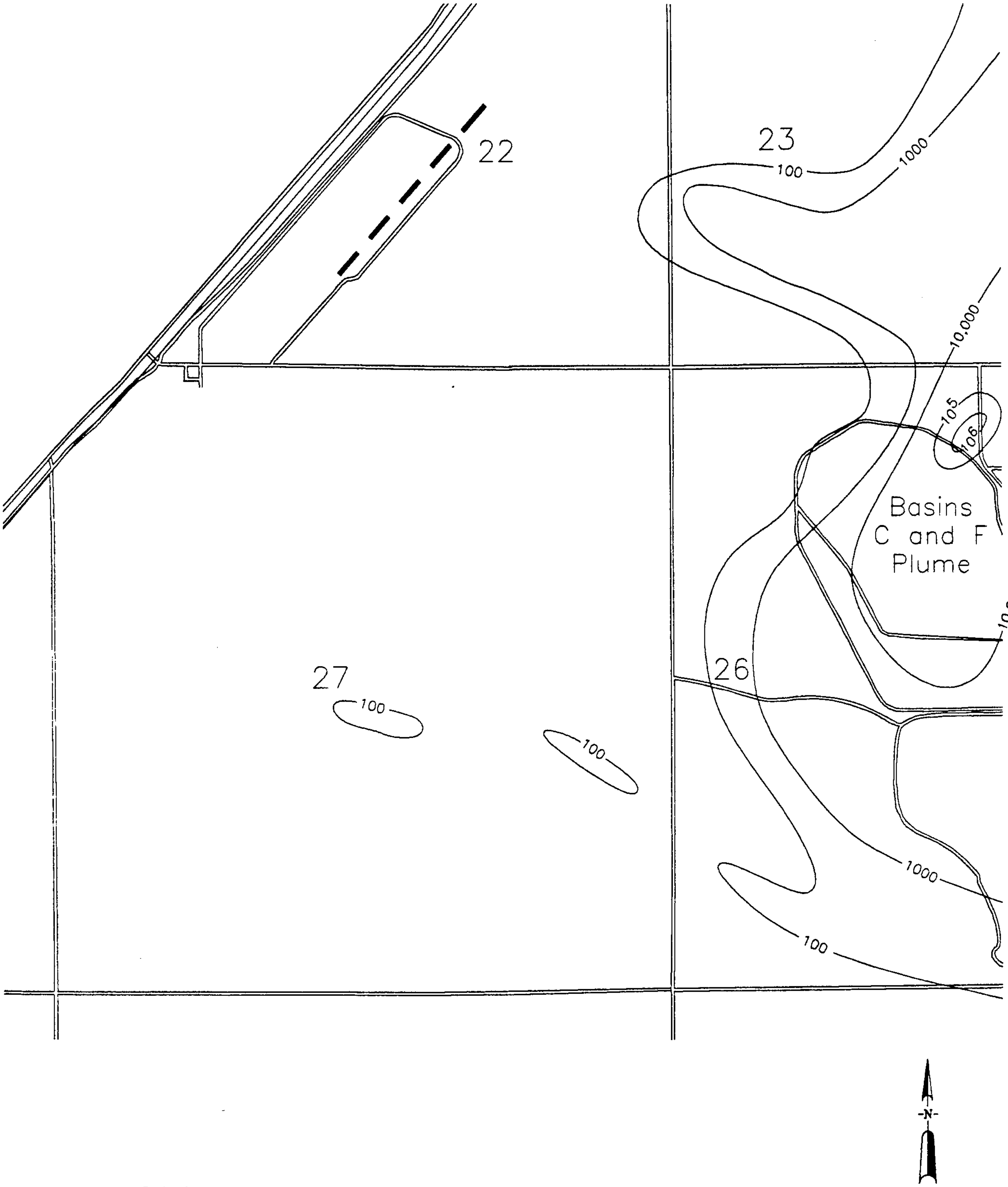
4.2.2.7 Cost

The costs for this alternative include continued operation of the NWBCS. The annual O&M costs are $1,270,000, and the 30-year present worth cost is $20,100,000. A summary of these costs is presented in Appendix A, Table A1-2.

Table 4.0-1 Comparative Analysis of Alternatives: Northwest Boundary Plume Group

Criteria	ALT NWC-1 No Action	ALT NWC-2 Continued Existing Action
1. Overall protection of human health and the environment	Does not meet RAOs at the boundary; contamination free to migrate off post	Reduces potential exposure to acceptable levels
2. Compliance with ARARs –Action-specific –Location-specific –Chemical-specific –Criteria, advisories, and guidance	Complies with location-specific ARARs but not chemical-specific ARARs; action-specific ARARs do not apply	Complies with action-, location-, and chemical-specific ARARs
3. Long-term effectiveness and permanence –Magnitude and residual risks –Adequacy and reliability of controls	Potential for off-post exposure due to contaminant migration Existing controls removed	NWBCS minimizes potential for off-post exposure Adequate controls, but long-term maintenance required
4. Reduction of TMV –Treatment process used and materials treated –Degree and quantity of TMV reduction –Irreversibility of TMV reduction	No treatment undertaken TMV reduced over time by natural attenuation	Contaminants removed by GAC adsorption at NWBCS 950 gpm removed and treated at NWBCS Contaminants irreversibly transferred to GAC, which requires regeneration
5. Short-term effectiveness –Protection of workers during remedial action –Protection of community during remedial action –Environmental impacts of remedial action –Time until RAOs are achieved	Minimal negative impact on workers and surrounding community Contamination free to migrate off post Natural attenuation of untreated groundwater ongoing, but does not meet RAOs	Minimal negative impact on workers and surrounding community No additional impact on environment Achieves RAOs; system may be required to operate at least 30 years
6. Implementability –Technical feasibility –Administrative feasibility –Availability of services and materials	Technically feasible Not administratively feasible: does not comply with FFA	Technically and administratively feasible Already operational
7. Costs		
–Capital Cost	$48,000	$0
–Annual O&M Cost	$37,500	$1,270,000
–Present Worth	$647,000	$20,100,000

ARAR	Applicable or Relevant and Appropriate Requirement
FFA	Federal Facility Agreement
GAC	Granular Activated Carbon
gpm	Gallons Per Minute
NWBCS	Northwest Boundary Containment System
O&M	Operation and Maintenance
RAO	Remedial Action Objective
TMV	Toxicity, Mobility, or Volume



Not To Scale

LEGEND

—100—	Summed Concentration of organic analytes (Table 3.1−2) in unconfined aquifer (ug/L)
▬ ▬	Perforated Slurry Wall

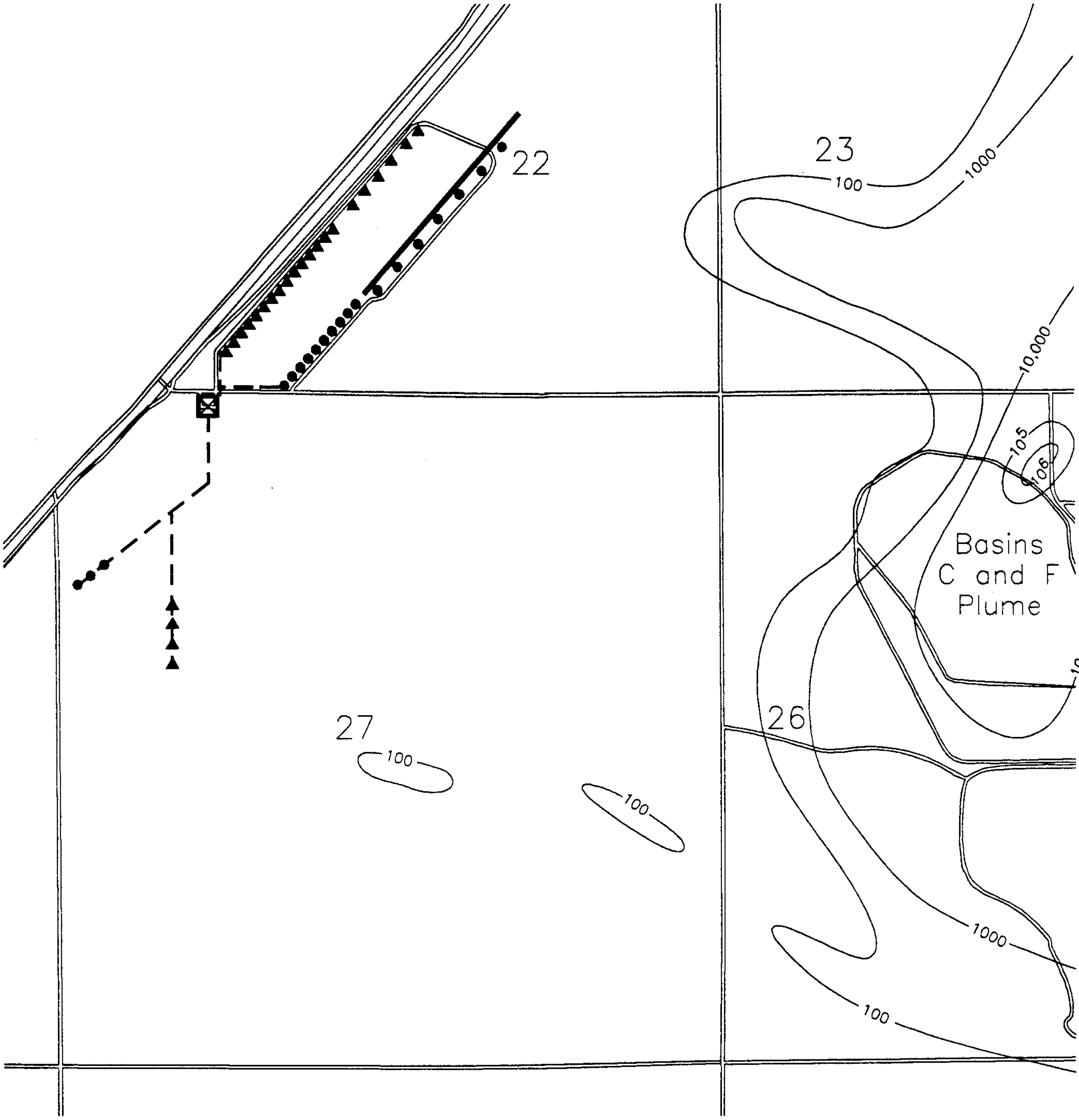
SOURCE: Water DSA Plume Map

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 4.1−1

Schematic for Northwest Boundary Plume Group Control Alternative NWC−1

Prepared by:
EBASCO SERVICES INCORPORATED



LEGEND

‾100‿	Summed Concentration of organic analytes (Table 3.1–2) in unconfined aquifer (ug/L)
●	Extraction Well
▲	Injection Well
▬	Slurry Wall
— — —	Transport Pipe
☒	Treatment Plant

SOURCE: Water DSA Plume Map

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 4.2–1

Schematic for Northwest Boundary Plume Group Control Alternative NWC–2

Prepared by:
EBASCO SERVICES INCORPORATED

5.0 WESTERN PLUME GROUP

The Western Plume Group consists of three plumes—the Western, Railyard, and Motor Pool Plumes—that coalesce southeast of the ICS, which is located in the northwestern corner of Section 33 along the RMA boundary. No contaminants exceed the PECs for this plume group. Three control systems are currently in place and operating to capture and treat contamination in these plumes, the ICS and two IRAs. The largest of these systems is the ICS, which was designed to remove DBCP from the groundwater using GAC adsorption. Four additional extraction wells, an upgrade to the ICS, have been constructed approximately 2,000 ft upgradient of the existing ICS. More recently, two IRA extraction systems have been constructed to control contaminant sources in the area: the Rail Classification Yard IRA was constructed to capture DBCP, and the Motor Pool Area IRA was constructed to capture trichloroethylene contamination. Extraction wells from the Motor Pool Area and Rail Classification Yard IRAs pump water to the ICS for treatment by GAC adsorption prior to reinjection at the ICS. Section 5.2 discusses the many modifications to the ICS in more detail.

The following sections provide detailed descriptions and analyses for each of the two alternatives retained from the Water DSA for the Western Plume Group. Table 5.0-1 presents a summary of the analyses. Only two alternatives were retained in the Water DSA due to low contaminant concentrations. In the DAA, plume characteristics were again compared to the PECs (Table 1.3-1) and were found not to warrant additional alternative development and analysis.

5.1 ALTERNATIVE WC-1: NO ACTION

Alternative WC-1 consists of discontinuing operation of the existing ICS and any planned upgrades and discontinuing any existing and planned IRAs.

5.1.1 Description of Alternative

This alternative does not include any current or future remedial activities, and any such activities that are in place are discontinued. The ICS is currently in place to prevent off-post migration of the contaminants within the Western Plume Group. This is a pump-and-treat system that uses

extraction wells, GAC adsorption (to remove organic contaminants), and reinjection wells. Two IRAs that supplement the ICS became operational in September 1991, the Rail Classification Yard IRA and the Motor Pool Area IRA (MKE 1992a). The Rail Classification Yard IRA consists of extraction wells upgradient of the ICS that pump water from the Railyard Plume. Similarly, the Motor Pool Area IRA uses extraction wells upgradient of the ICS to pump water from the Motor Pool Plume. Extracted water from both of these plumes is piped to the ICS for treatment and reinjection.

Under this alternative, operation of the ICS and the two IRAs is discontinued. Dismantling or future use of remedial action support structures, such as ICS treatment buildings, are included as part of the No Future Use, Manufacturing History Medium Group in the Structures DAA. A groundwater monitoring program using 15 existing wells is conducted. Figure 5.1-1 presents the No Action alternative.

No treatment is associated with this alternative. Current treatment with GAC is discontinued.

5.1.2 Analysis of Alternative

5.1.2.1 Overall Protection of Human Health and the Environment

This alternative does not ensure protection of human health and the environment since it involves elimination of both the ICS capture and treatment system and the Motor Pool Area and Rail Classification Yard IRAs, systems that rely on the ICS for treatment. Elimination of current controls results in increased contaminant migration on post and off post.

5.1.2.2 Compliance with ARARs

Action-specific ARARs listed in the Technology Description Volume, Appendix A, are not relevant if Alternative WC-1 is chosen because contaminated groundwater is not extracted and treated at the ICS to achieve PRGs. This alternative is not in compliance with the FFA, nor does it comply with all potential chemical-specific ARARs listed in Appendix A, Volume I of the

Water DSA. This alternative complies with location-specific ARARs listed in Appendix A, Volume I of the Water DSA.

5.1.2.3 Long-Term Effectiveness and Permanence

The lack of groundwater controls and treatment leads to a potential for off-post exposure as a result of unrestricted contaminant migration. All existing controls are removed.

5.1.2.4 Reduction of TMV

This alternative does not provide any significant reduction in contaminant TMV since no active extraction/treatment is undertaken. The removal of existing controls results in increased contaminant migration and increased contaminant TMV. There may, however, be a slight reduction in TMV over time as a result of natural attenuation. Natural attenuation is responsible for some potential reduction in contaminant levels, but will not have significant impact on contaminant concentrations.

5.1.2.5 Short-Term Effectiveness

There is minimal exposure to workers, the surrounding community, or the environment associated with shutdown of the ICS and the Motor Pool Area and Rail Classification Yard IRAs. The protection that is currently provided through the ICS and the Rail Classification Yard and Motor Pool Area IRAs is eliminated, resulting in potential increase in contaminant levels. RAOs are not achieved through this alternative.

5.1.2.6 Implementability

Alternative WC-1 is technically feasible. However, since it does not meet RAOs and is not in compliance with the FFA, it is not administratively feasible.

5.1.2.7 Costs

There is no capital cost associated with this alternative. The O&M costs associated with monitoring amount to $51,500 per year, and the present worth cost is $920,000. A summary of these costs is presented in Appendix A, Table A2-1.

5.2 ALTERNATIVE WC-2: CONTINUED EXISTING ACTION

Alternative WC-2 includes continued operation of the existing treatment systems for the Western Plume Group. This includes the ICS, the Rail Classification Yard IRA, and the Motor Pool Area IRA. In addition, groundwater monitoring is continued and provisions of the FFA are enforced.

5.2.1 Description of Alternative

5.2.1.1 Extraction/Reinjection

Originally, the ICS consisted of two rows of extraction wells and one row of recharge wells. A number of modifications to the ICS system configuration were completed by 1991 to arrive at the current system (Figure 5.2-1). Nine new recharge wells, which reduce the water table depression caused by heavy SACWSD pumping rates and enlarge the zone of captured groundwater on the south edge of the ICS, were installed south of the original system and became operational in June 1991. Additionally, four new extraction wells were installed 2,000 ft upgradient of the original ICS and became operational in April 1991 in an area of greater saturated thickness than the original ICS extraction wells. These wells are referred to as the east row of extraction wells. The east row of extraction wells are located so that the SACWSD pumping has a minimal effect on the capture of the Motor Pool and Railyard Plumes, allowing the wells to operate at a more consistent extraction rate. Finally, an existing extraction well in the original system was changed to become a recharge well (MKE 1992a). Currently, only the four newly installed extraction wells in the east row are operating, pumping approximately 505 gpm of groundwater. The original extraction wells have been completely turned off. The total flow rate of the system, when combined with the Rail Classification Yard and Motor Pool Area IRAs, is approximately 870 gpm.

IRA system modifications include the installation of seven new extraction wells under the Rail Classification Yard IRA to intercept DBCP contamination, and two extraction wells installed under the Motor Pool IRA to intercept a trichloroethylene plume. These wells became operational in September 1991. Five of the seven wells in the Rail Classification Yard IRA are pumping at a total rate of approximately 265 gpm; the two other wells that have not been used are backup extraction wells. The two wells in the Motor Pool area are pumping approximately 100 gpm. The total of 365 gpm groundwater extracted from the Motor Pool Area and Rail Classification Yard extraction wells is manifolded and pumped from a pumping station to the ICS by pressure flow.

5.2.1.2 Treatment

All groundwater extracted from the Western Plume Group is treated at the ICS. The water is collected in an influent sump located adjacent to the treatment plant building. Two 700-gpm influent pumps feed two parallel 700-gpm treatment trains. Each treatment train consists of three cartridge prefilters, one GAC absorber, and three cartridge postfilters. Two banks of bag guard filters are used by each treatment train. The GAC adsorbers are 10 ft in diameter, 16 ft high, and contain 42,000 lbs of carbon each; they are operated in the upflow mode with a contact time of 15 minutes.

In 1991, 32,000 lbs, 11,400 lbs, and 9,600 lbs of carbon were added to absorber V-101, V-102, and V-103, respectively (MKE 1992a). Each pound of carbon treated approximately 12,000 gallons of water. The third carbon bed was available on standby.

To allow for additional flow resulting from the Rail Classification Yard and Motor Pool Area IRAs, the capacity of the treatment system was increased by bringing the existing third GAC bed online, although this option has not been required with present flow rates (the ICS is currently treating approximately 870 gpm). With all three trains operating in parallel, the ICS has a maximum design capacity of 2,100 gpm.

5.2.1.3 Sidestreams

The ICS generates two sidestreams requiring treatment or disposal, spent carbon and filter solids. The spent carbon in the adsorbers is removed and regenerated at an off-post facility. The filter solids and cartridge filters are drummed and disposed in a RCRA-approved landfill off post.

5.2.2 Analysis of Alternative

5.2.2.1 Overall Protection of Human Health and the Environment

Alternative WC-2 involves continued operation of the ICS and the Motor Pool Area and Rail Classification Yard IRAs to ensure that potential exposure is reduced to acceptable levels at the RMA boundary, thereby protecting human health and the environment off post. Continued extraction from the Railyard and Motor Pool Plumes reduces the migration of contaminated water and protects the environment on post. Human health is protected on post by the FFA, which prohibits the use of RMA groundwater as potable water.

5.2.2.2 Compliance with ARARs

This alternative is in compliance with all potential action-specific ARARs listed in the Technology Description Volume, Appendix A, including those related to the extraction systems and air emission controls, because it uses an existing system that complies with these ARARs. The existing system also complies with all chemical-specific ARARs listed in Appendix A, Volume I of the Water DSA and the FFA so long as PRGs are achieved at the RMA boundary through continued operation of the ICS. Continued operation of the ICS also ensures compliance with all potential location-specific ARARs applicable to groundwater, which are listed in Appendix A, Volume I of the Water DSA.

5.2.2.3 Long-Term Effectiveness and Permanence

Continued operation of ICS reduces the potential for off-post exposure to acceptable levels, and the controls provided by this alternative are adequate. The system may be required to operate more than 30 years, although extraction from the Railyard and Motor Pool Plumes reduces the time needed for operation of the ICS.

5.2.2.4 Reduction of TMV

The contaminated groundwater is extracted and treated by GAC adsorption at a rate of 870 gpm, which results in a significant reduction of contaminant TMV. The contaminants are irreversibly transferred to GAC, which requires regeneration off post.

5.2.2.5 Short-Term Effectiveness

This alternative has minimal negative impact on workers and surrounding communities since no additional actions are undertaken and no existing actions are removed. There is no additional impact on the environment. This alternative achieves RAOs through continued operation of the ICS. The system may be required to operate more than 30 years, although extraction from the Railyard and Motor Pool Plumes reduces the time needed for operation of the ICS.

5.2.2.6 Implementability

The system is already operational, and continued operation is technically and administratively feasible.

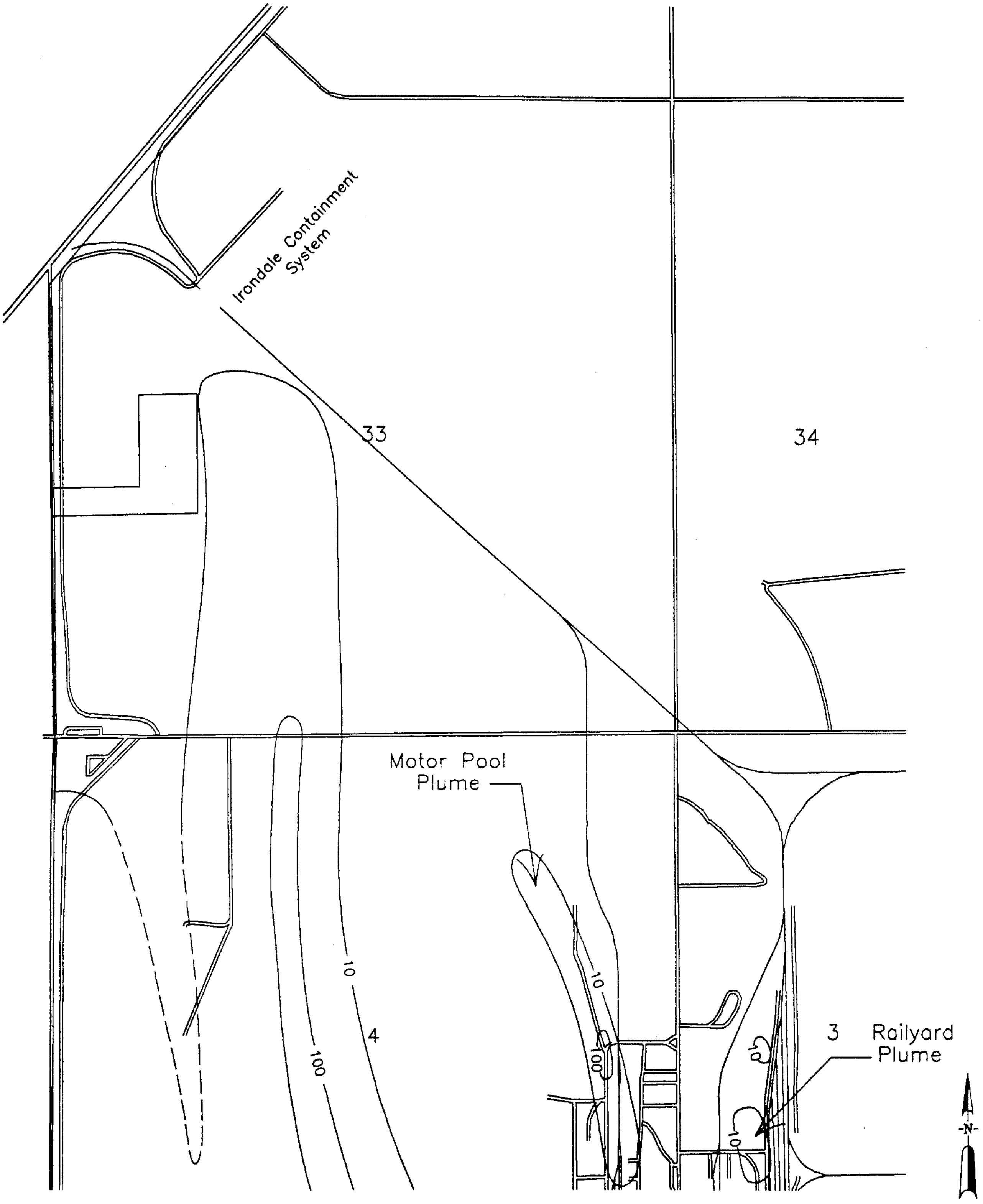
5.2.2.7 Costs

There is no capital cost associated with this alternative. The O&M costs are $911,000 per year, and the present worth cost is $14,500,000. These costs are summarized in Appendix A, Table A2-2.

Table 5.0-1 Comparative Analysis of Alternatives: Western Plume Group

Criteria	ALT WC-1 No Action	ALT WC-2 Continued Existing Action
1. Overall protection of human health and the environment	Does not meet RAOs at the boundary; contamination free to migrate off post	Reduces potential exposure to acceptable levels
2. Compliance with ARARs - Action-specific - Location-specific - Chemical-specific - Criteria, advisories, and guidance	Does not comply with chemical-specific ARARs or the FFA; complies with location-specific ARARs Action-specific ARARs do not apply	Complies with action-, location-, and chemical-specific ARARs and the FFA
3. Long-term effectiveness and permanence		
- Magnitude and residual risks	Potential for off-post exposure due to contaminant migration	ICS minimizes potential for off-post exposure
- Adequacy and reliability of controls	Existing controls removed	Adequate controls, but long-term maintenance required
4. Reduction of TMV		
- Treatment process used and materials treated	No treatment undertaken	Contaminants in groundwater removed by GAC adsorption at ICS
- Degree and quantity of TMV reduction	TMV reduced over time by natural attenuation	870 gpm removed and treated at ICS
- Irreversibility of TMV reduction		Contaminants irreversibly transferred to GAC, which requires regeneration
5. Short-term effectiveness		
- Protection of workers during remedial action	Minimal negative impact on the environment, surrounding community, and worker protection	Minimal negative impact on workers and surrounding community
- Protection of community during remedial action	Contamination free to migrate off post	No additional impact on environment
- Environmental impacts of remedial action - Time until RAOs are achieved	Natural attenuation of untreated groundwater ongoing, but does not meet RAOs	Achieves RAOs; system may be required to operate at least 30 years
6. Implementability		
- Technical feasibility	Technically feasible	Technically and administratively feasible
- Administrative feasibility - Availability of services and materials	Not administratively feasible: does not comply with FFA	Already operational
7. Costs		
- Capital cost	$0	$0
- Annual O&M cost	$57,500	$911,000
- Present worth	$920,000	$14,500,000

ARAR	Applicable or Relevant and Appropriate Requirement
FFA	Federal Facility Agreement
GAC	Granular Activated Carbon
ICS	Irondale Control System
RAO	Remedial Action Objective
TMV	Toxicity, Mobility, or Volume



Not To Scale

SOURCE: Water DSA Plume Map

LEGEND

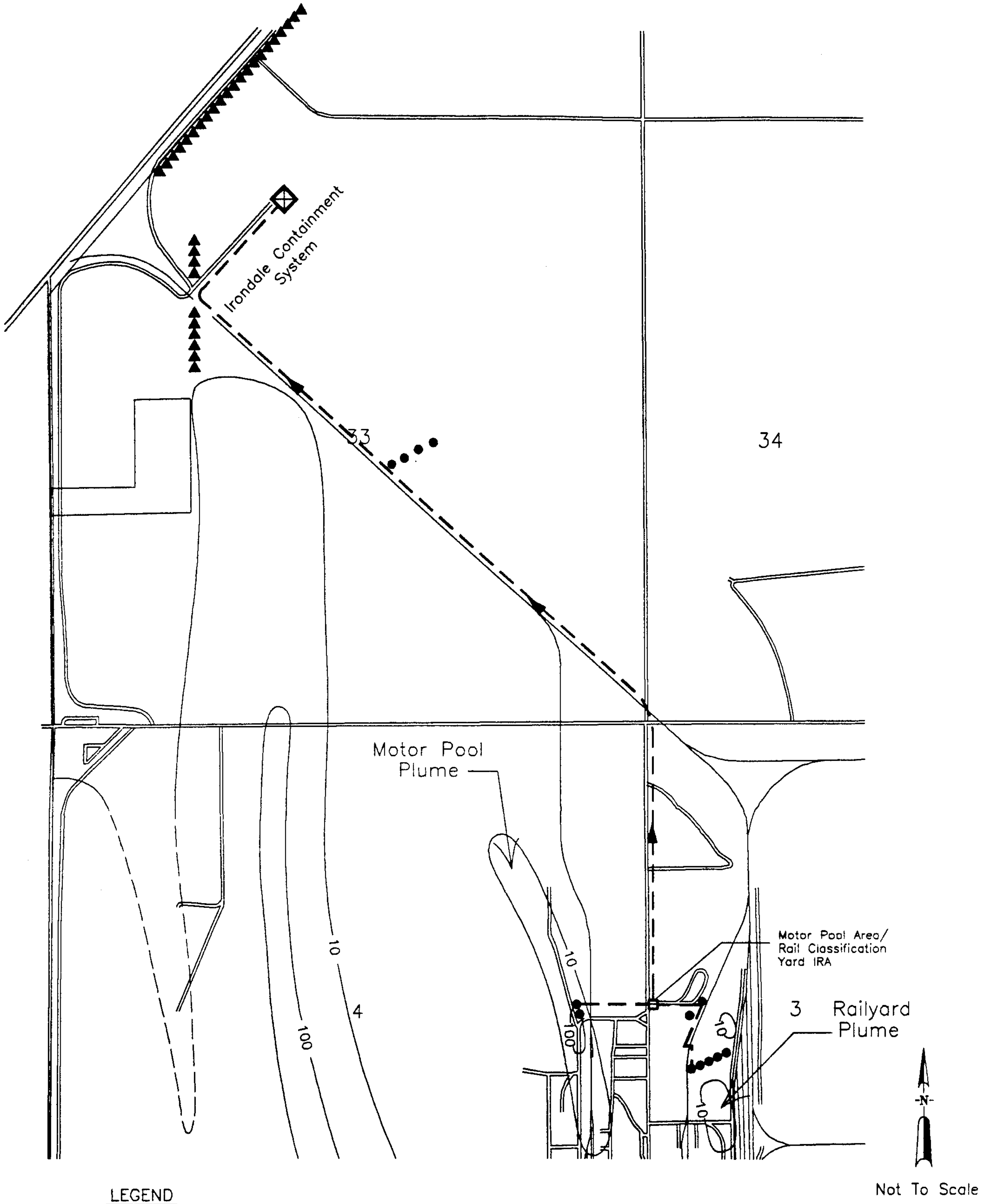
—100 Summed Concentration of organic analytes (Table 3.1–2) in unconfined aquifer (ug/L)

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 5.1–1

Schematic for Western Plume Group Control Alternative WC–1

Prepared by:
EBASCO SERVICES INCORPORATED



LEGEND

100	Summed Concentration of organic analytes (Table 3.1-2) in unconfined aquifer (ug/L)
●	Extraction Well
▲	Injection Well
— — —	Transport Pipe
☒	Treatment Plant

SOURCE: Water DSA Plume Map

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 5.2-1
Schematic for Western Plume Group
Control Alternative WC-2

Prepared by:
EBASCO SERVICES INCORPORATED

6.0 NORTH BOUNDARY PLUME GROUP

Six alternatives were retained from the Water DSA for consideration in the Water DAA for the North Boundary Plume Group. Four of the six alternatives were modified as a result of new groundwater-flow information and chemical analysis information obtained during the Water DAA. Based on additional analysis of groundwater flow in this area, groundwater extraction rates are now projected to be significantly lower than those estimated in the Water DSA. One modification that impacts a majority of the alternatives is that water in the North Plants Plume is not intercepted because contaminant concentrations do not exceed the PECs. Another modification is that the predicted extraction rate for water from the Basins C and F area is low enough that the extracted water can be treated with existing facilities, either at the NBCS or the Basin F Groundwater/Basin A Neck IRA treatment facility.

The North Boundary Plume Group includes two plumes, the North Plants Plume and the Basins C and F Plume. The Basins C and F Plume is the most contaminated, chloroform being the primary contaminant. Contaminated groundwater migrates northward, primarily through the saturated alluvium and to a lesser extent through the upper weathered portion of the Denver Formation. In this area, the extent of contamination in the weathered Denver Formation appears to be limited, requiring little or no action. No contaminants in the North Plants Plume are present at mean concentrations that exceed the PECs.

The NBCS, currently in place, prevents off-post migration of the contaminants within the North Boundary Plume Group. This is a pump-and-treat system that uses 35 on-post extraction wells to remove contaminated groundwater that is treated by GAC adsorption and reinjected into on-post reinjection trenches. The system includes a 6,740-ft slurry wall between the extraction and reinjection wells to prevent recirculation of the groundwater. Two IRAs associated with the North Boundary Plume Group have been implemented. The first IRA consists of modifications to the NBCS. The second IRA, known as the Basin F Groundwater IRA, consists of an extraction well north of Basin F from which groundwater is piped to the Basin A Neck IRA

treatment facility where it is treated by air stripping and GAC adsorption. Section 6.2 presents a more detailed description of the NBCS and the IRAs.

The following sections provide detailed descriptions and analyses for each of the six alternatives retained from the Water DSA for the North Boundary Plume Group. Table 6.0-1 presents a summary of the comparative analyses.

6.1 ALTERNATIVE NC-1: NO ACTION

Alternative NC-1 consists of discontinuing operation of the existing NBCS and any planned upgrades and discontinuing operation of the Basin F Groundwater IRA.

6.1.1 Description of Alternative

Under the No Action alternative, operation of the NBCS is discontinued. The slurry wall is breached with approximately nine permeable trenches, allowing the aquifer to return to its natural state (Figure 6.1-1) and preventing an increase in hydraulic head in the contaminated alluvial aquifer that could result in contaminated alluvial water entering the Denver Formation. In addition, the groundwater currently being pumped away from the Basin F area by the Basin F Groundwater IRA returns to its natural flow through the alluvial channel. An annual groundwater monitoring program using 20 existing wells is conducted. No treatment is associated with this alternative since current GAC treatment at the NBCS is discontinued. Dismantling remedial support structures, such as the NBCS, are included as part of the No Future Use, Manufacturing History Medium Group in the Structures DAA.

6.1.2 Analysis of Alternative

6.1.2.1 Overall Protection of Human Health and the Environment

This alternative does not ensure protection of human health and the environment since it involves elimination of the NBCS, thereby allowing contaminants to migrate off post.

6.1.2.2 Compliance with ARARs

Action-specific ARARs listed in the Technology Description Volume, Appendix A are not relevant if the No Action alternative is chosen. Because contaminated groundwater is not extracted and treated at the NBCS to achieve PRGs, this remedial alternative does not comply with all potential chemical-specific ARARs listed in Appendix A, Volume I of the Water DSA, nor does it comply with the FFA. However, this alternative is in compliance with all potential location-specific ARARs listed in Appendix A, Volume I of the DSA.

6.1.2.3 Long-Term Effectiveness and Permanence

The lack of groundwater controls and treatment under this alternative results in a potential for off-post exposure because of unrestricted contaminant migration across RMA boundaries. The protection that is currently provided by the NBCS is eliminated, resulting in a potential increase in contaminant levels. Natural attenuation may occur but it will not significantly reduce contaminant concentrations to achieve PRGs.

6.1.2.4 Reduction of TMV

Alternative NC-1 does not provide any significant reduction in contaminant TMV since no remedial actions are undertaken. Compared to current conditions, there is an increase in contaminant TMV because of increased contaminant migration. There may be some reduction of contaminant levels over time as a result of natural attenuation processes.

6.1.2.5 Short-Term Effectiveness

There will be some potential exposure to workers during activities associated with breaching of the slurry wall, but risks can be adequately reduced through use of personal protective equipment (PPE). The activities involved in this alternative do not have any significant impact on the surrounding community. RAOs are not achieved through this alternative.

6.1.2.6 Implementability

Alternative NC-1 is technically feasible. However, since it does not meet RAOs and it is not in compliance with the FFA, it is not administratively feasible.

6.1.2.7 Costs

The capital cost associated with this alternative is $166,000. Annual O&M costs are $75,000, and the present worth cost is $1,360,000. A cost summary is presented in Appendix A, Table A3-1.

6.2 ALTERNATIVE NC-2: CONTINUED EXISTING ACTION

Alternative NC-2 includes continued operation of the existing treatment systems for the North Boundary Plume Group. These consist of the NBCS and two ongoing IRAs—the modifications to the NBCS and the control of groundwater at the Basin F Groundwater IRA. Continued groundwater monitoring and continued compliance with the FFA are also included.

6.2.1 Description of Alternative

6.2.1.1 Extraction/Reinjection

The NBCS is a pump-and-treat system that consists of 35 extraction wells ranging in depth to 35 ft, and a 6,740-ft-long, 3-ft-wide, 30-ft-deep soil/bentonite slurry wall. The extracted water is treated at the treatment plant with GAC and recharged through 15 reinjection trenches. The NBCS was upgraded as a result of an assessment completed as part of the IRA for this system. The upgraded system has an improved treatment system, five new recharge trenches (installed in 1990) and ten recharge trenches (installed in 1988). The trenches extend along the system located about 45 ft north of the existing soil/bentonite slurry wall. The existing recharge wells are not in operation, but can be used as backups if the trenches fail. The trenches were installed close to the slurry wall to better maintain a reverse gradient. Current flow through the treatment plant averages 280 to 300 gpm (James 1993).

The Basin F Groundwater IRA was implemented to capture contamination moving north out of the Basin F area. Water is extracted using one well at a rate of 1 to 4 gpm, and is then piped to the Basin A Neck IRA system. Figure 6.2-1 presents a schematic of this alternative.

6.2.1.2 Treatment

The treatment for this alternative is accomplished at the NBCS and at the Basin A Neck IRA treatment facility. The treatment plant at the NBCS originally included prefiltration units, three 30,000-lb GAC adsorbers operated in parallel, and a combination of cartridge and bag postfilters. Treated effluent is discharged to a sump for groundwater recharge. The treatment plant has undergone minor operational changes (associated mostly with carbon handling) and now has two 30,000-lb GAC adsorbers operated in parallel, with the third unit available as a backup. The GAC units operate in upflow mode, and the estimated carbon usage is 20,000 lbs per month. The total capacity of the modified extraction/treatment system is estimated to be 450 gpm.

The treatment system for the Basin F groundwater treated at the Basin A Neck IRA includes an air stripper, a vapor-phase treatment unit, GAC adsorption, and bag filters for prefiltration and postfiltration. A scaling inhibitor is added to the stripper influent to prevent scale buildup in the stripper.

6.2.2 Analysis of Alternative

6.2.2.1 Overall Protection of Human Health and the Environment

The NBCS captures and treats contaminants at the north boundary of RMA, thereby ensuring adequate protection of human health and the environment off post by reducing exposure potential. The Basin F Groundwater IRA reduces migration of highly contaminated on-post groundwater toward the boundary. Human health is protected on post by the FFA, which prohibits the use of RMA groundwater as potable water.

6.2.2.2 Compliance with ARARs

This remedial alternative is in compliance with all potential action-specific ARARs listed in the Technology Description Volume, Appendix A, including those related to the extraction systems and air emission controls, because it uses an existing system that complies with these ARARs. The existing system also complies with all chemical-specific ARARs listed in Appendix A, Volume I of the Water DSA report and the FFA so long as PRGs are achieved at the RMA boundary through continued operation of the NBCS. The NBCS complies with all potential location-specific ARARs applicable to groundwater, which are listed in Appendix A, Volume I of the Water DSA report.

6.2.2.3 Long-Term Effectiveness and Permanence

Controls implemented through the NBCS and Basin F Groundwater IRA minimize the potential for off-post exposure. RAOs are achieved with this alternative, but the NBCS extraction and treatment system will need to continue operation until contaminant concentrations in the influent are below PRGs, at which time the system can be turned off. Since the NBCS relies on natural groundwater gradients and flow to capture contaminants, it is anticipated that this will not occur for 100 or more years.

6.2.2.4 Reduction of TMV

Contaminants are removed from water through GAC adsorption at the NBCS and through air stripping and GAC adsorption at the Basin F Groundwater/Basin A Neck IRA treatment system, thereby ensuring a reduction in contaminant TMV. Water is extracted and treated at a flow rate of approximately 300 gpm at the NBCS and 1- to 4-gpm at the Basin F Groundwater IRA. Contaminants are irreversibly transferred to GAC, which requires regeneration.

6.2.2.5 Short-Term Effectiveness

There are no changes to the system that is currently operating at RMA. Consequently, implementation of this alternative has minimal impact on workers, the community, and the environment.

RAOs are achieved through operation of the NBCS. However, the system may have to operate for more than 100 years.

6.2.2.6 Implementability

The NBCS and Basin F Groundwater IRA are already operational and will continue to operate in the current function. This alternative is, consequently, both technically and administratively feasible.

6.2.2.7 Costs

There is no capital cost associated with Alternative NC-2. The O&M costs are $2,590,000 per year, and the corresponding present worth cost is $41,200,000. The costs for this alternative are summarized in Appendix A, Table A3-2.

6.3 ALTERNATIVE NC-3/NT-2: INTERCEPTION, TREATMENT AT NBCS

This alternative consists of groundwater extraction from the Basins C and F Plume and treatment at the NBCS. Table 6.3-1 presents the estimated influent concentrations for the combined flow of groundwater extracted from the Basins C and F Plume and for groundwater extracted at the NBCS.

6.3.1 Description of Alternative

6.3.1.1 Extraction/Reinjection

Alternative NC-3 includes installation and operation of a groundwater extraction system that incorporates the existing Basin F Groundwater IRA extraction well. Under Alternative NC-3/NT-2, extracted groundwater is transferred to the NBCS for treatment. The NC-3 extraction system removes contaminants in proximity to sources in Basins C and F, thereby reducing the migration of contaminants through Section 23 and lowering the water table near the extraction system. As a result of the groundwater flow and contaminant loading analysis performed as part of the Water DAA, this alternative no longer includes an extraction system at North Plants or a recharge trench in the Basin F area as it did in the Water DSA. Groundwater

is treated at the existing NBCS under treatment Alternative NT-2; inorganics are not treated because PRGs are achieved at the boundary.

The extraction system consists of six newly installed wells and the existing Basin F Groundwater IRA extraction well. The wells are located along an approximate east-west line that crosses Ninth Avenue (Figure 6.3-1). All extraction wells under this alternative are constructed using 12-inch-diameter borings with gravel pack surrounding the 6-inch diameter casing and screen (thereby increasing the effective intake radius of the screen). All pipelines are double walled, all submersible pumps in wells are one-third horsepower, and all booster pumps are 1.5 horsepower. The wells are approximately 60 ft deep with 15-ft screened intervals in the weathered bedrock, extending into the overlying saturated alluvium (if present). Groundwater is extracted at a total rate of approximately 6 gpm over the entire well field. Water is pumped from each well to a collection tank and is then transferred to the NBCS for treatment and injection into the existing NBCS recharge trenches.

Groundwater-quality and water-level data from a monitoring network of existing plume evaluation monitoring wells and newly installed performance monitoring wells are used to evaluate the effectiveness and operation of the extraction system. The final location of the new wells is based upon review of existing well locations and screened intervals.

Alternative NC-3 is an addition to the existing Basin F Groundwater IRA and provides greater capture of groundwater flow in proximity to the Basins C and F source areas. Saturated alluvium in this area is generally 0 to 2 ft thick. Operation of the extraction system lowers the water table, reducing the saturated thickness of the alluvium locally. When this occurs, groundwater flows primarily in the weathered bedrock and flow rates to the extraction system are reduced. This low flow system provides good source control in the Basins C and F area.

The groundwater extracted from the Basins C and F Plume is recharged to the aquifer through the existing 15 recharge trenches at the NBCS.

6.3.1.2 Treatment

The 6-gpm flow is added to the NBCS 280 to 300 gpm influent. Table 6.3-1 shows the contaminant concentrations of the NBCS influent after the Basins C and F water is added. The overall impact on the current performance of the NBCS is negligible.

6.3.1.3 Sidestreams

This alternative does not generate any additional sidestreams beyond those that currently exist at the NBCS. The additional carbon consumption required to treat the Basins C and F water is insignificant.

6.3.2 Analysis of Alternative

6.3.2.1 Overall Protection of Human Health and the Environment

Human health and the environment are protected off post by operation of the NBCS, which captures and treats groundwater at the north boundary before it migrates off-post, minimizing the risk for potential exposure to contaminated groundwater. This alternative provides additional protection by removing highly contaminated groundwater on post and treating it at the NBCS.

Human health is protected on post by the FFA, which prohibits the use of RMA groundwater as potable water. The environment is also protected on post when groundwater containing organochlorine pesticides (OCPs) is extracted and piped to the existing NBCS treatment system where the contaminants are irreversibly removed with GAC. Extracting contaminated groundwater from the Basins C and F Plume upgradient of the NBCS reduces the potential for this contamination to spread on post before it migrates across the boundary. Although the Basin F Groundwater IRA extraction well already intercepts and extracts contaminated groundwater for treatment, the proposed system intercepts groundwater over a larger area and treats a larger volume of groundwater, thus increasing the mass of contamination that is removed from that plume. The Basin F Groundwater IRA extraction well is already operating at this location and groundwater is treated at the Basin A Neck IRA. Operation of the NBCS reduces contaminant concentrations in the water to acceptable levels before it moves off post.

6.3.2.2 Compliance with ARARs

This alternative is in compliance with all potential action-specific ARARs listed in the Technology Description Volume, Appendix A, including those related to the extraction systems and air emission controls, because it only expands an existing extraction well system and treats groundwater with an existing treatment system, both of which comply with these ARARs. The treatment system also complies with all potential chemical-specific ARARs listed in Appendix A, Volume I of the Water DSA and the FFA so long as PRGs are achieved at the RMA boundary through continued operation of the NBCS. The NBCS and the expanded Basin F Groundwater IRA system provide compliance with all potential location-specific ARARs applicable to groundwater, which are listed in Appendix A, Volume I of the Water DSA.

6.3.2.3 Long-Term Effectiveness and Permanence

This alternative removes contaminants permanently from the aquifer through GAC adsorption. The alternative includes continued operation of the NBCS and an expansion of the already existing and operating Basin F Groundwater IRA. The extraction and treatment systems continue to operate until contaminant concentrations in the influent are below PRGs, at which time the systems are turned off. Since the extraction well system relies on natural groundwater gradients and flow to capture contaminants, it is anticipated that this will not occur for 100 or more years for both the Basins C and F extraction system (the expanded Basin F Groundwater IRA) and the NBCS due to the low rate of migration of the contaminants.

It should be noted that although contaminants are removed more rapidly by this alternative than by Alternative NC-2, additional contamination may leach into the groundwater from the soil in the unsaturated zone or may desorb into the groundwater from soil in the saturated zone. Thus, contaminant toxicity and mobility may only decrease very slowly since the contaminants are removed by the treatment system at the same time as they are partially replenished from the environment.

6.3.2.4 Reduction of TMV

This alternative reduces contaminant TMV to a greater extent than the existing Basin F Groundwater IRA. Toxicity of the groundwater is reduced when contaminants are adsorbed to the GAC during treatment. Saturated carbon is thermally regenerated off post.

Mobility of contaminated groundwater is decreased on post when groundwater from the Basins C and F Plume is intercepted and extracted closer to the source of contamination than when extraction is performed at the NBCS. Extracting groundwater closer to the source prevents contaminants from dispersing and diluting through the aquifer and adsorbing to the soils, possibly desorbing later as groundwater migrates to the NBCS. Off-post migration of contaminated groundwater is also decreased through operation of the NBCS. As treatment continues, the volume of contaminated water is reduced.

6.3.2.5 Short-Term Effectiveness

Operation of this alternative has minimal negative impact on the environment, the surrounding community, and workers. The only construction required is the installation of extraction wells at the Basins C and F Plume and piping to the NBCS. These types of activities have been undertaken in the past with minimal impact on the environment and community. Because this alternative uses the existing NBCS for treatment and recharge, there are no additional impacts once the new extraction system is operational.

A potential exists for workers to be exposed to hazardous conditions during construction of the wells and piping; however, this is addressed by the on-post health and safety plan for the remedial construction.

6.3.2.6 Implementability

This alternative is both technically and administratively feasible. Extraction systems, transport systems, reinjection systems, and GAC adsorption are proven, reliable, and available technologies already in use at RMA. The NBCS is already in place and operating, so very little, if any,

additional training is needed for the plant personnel. All activities take place on post and are in accordance with the FFA.

6.3.2.7 Costs

The capital cost for this system is $764,000, and annual O&M costs are $2,710,000. The present worth cost is $43,900,000. The costs for this alternative are summarized in Appendix A, Table A3-3.

6.4 ALTERNATIVE NC-3/NT-3: INTERCEPTION, TREATMENT AT BASIN A NECK IRA

This alternative is similar to Alternative NC-3/NT-2 except that the groundwater extracted from the Basins C and F Plume (using the expanded Basin F Groundwater IRA) is treated at the Basin A Neck IRA treatment system. Table 6.4-1 presents the estimated chemical influent concentrations contributed by the Basins C and F Plume intercept system.

6.4.1 Description of Alternative

6.4.1.1 Extraction/Reinjection

This alternative includes the same groundwater control system that is used for Alternative NC-3/NT-2 with the exception of the location where the extracted water is piped and treated. Under Alternative NC-3/NT-3, the extracted groundwater is transferred to the existing Basin A Neck IRA for treatment and reinjection. The extracted groundwater is transferred through the piping already in place for the Basin F Groundwater IRA. Figure 6.4-1 presents a schematic of this alternative.

Treated water is recharged to the aquifer through the three existing recharge trenches of the Basin A Neck IRA. Water extracted and treated at the NBCS is recharged through the existing 15 trenches located at that system.

6.4.1.2 Treatment

The Basins C and F Plume groundwater is treated at the Basin F Groundwater/Basin A Neck IRA treatment facility using the existing equipment. The only difference is the increased flow rate used in this alternative. The water is first pumped through the air stripper where the volatile organics are transferred to the air stream and treated with vapor-phase carbon. The water effluent from the air stripper is mixed with the Basin A Neck IRA water and is treated in the liquid-phase GAC adsorbers.

6.4.1.3 Sidestreams

This treatment system produces two major sidestreams, vapor emissions from the air stripper and spent carbon from the adsorbers. Vapor-phase emissions from the air stripper are treated with vapor-phase GAC, which requires periodic replacement. Estimated GAC consumption for this unit is 2,500 lbs per year (or approximately seven 400-lb units). Spent carbon from the liquid-phase GAC units is collected by the vendor supplying the GAC and is regenerated off post. The additional carbon consumption for treating the Basins C and F Plume is 1,300 lbs per year.

6.4.2 Analysis of Alternative

6.4.2.1 Overall Protection of Human Health and the Environment

Human health and the environment are protected off post by operation of the NBCS, which captures and treats groundwater in the Basins C and F and North Plants Plumes before it migrates across the RMA boundary. This alternative also provides additional protection by extracting and treating contaminated groundwater on post, minimizing the risk for potential exposure to contaminated groundwater.

Human health is protected on post by the FFA, which prohibits the use of RMA groundwater as potable water. The environment is also protected on post because contaminated groundwater is extracted and piped to the existing Basin A Neck IRA treatment system where the contaminants are irreversibly removed with air stripping and GAC. Extracting contaminated groundwater from the Basins C and F Plume upgradient of the NBCS reduces the potential for this contamination

to spread on post. Although the Basin F Groundwater IRA extraction well already intercepts, extracts, and treats contaminated groundwater, the proposed system intercepts groundwater over a larger area and treats a larger volume of groundwater. Capturing the groundwater where it is most contaminated maximizes the mass of contaminant that is removed from that plume. The Basin F Groundwater IRA extraction well is already operating at this location and groundwater is treated at the Basin A Neck IRA. Operation of the NBCS reduces contaminant concentrations in the water to acceptable levels before it moves off post.

6.4.2.2 Compliance with ARARs

This alternative is in compliance with all potential action-specific ARARs listed in the Technology Description Volume, Appendix A, including those related to the extraction systems and air emission controls, because it only expands an existing extraction well system and treats groundwater with an existing treatment system, both of which comply with these ARARs. The treatment system also complies with all potential chemical-specific ARARs listed in Appendix A, Volume I of the Water DSA and the FFA so long as PRGs are achieved at the RMA boundary through continued operation of the NBCS. The NBCS and the expanded Basins C and F extraction well system comply with all potential location-specific ARARs applicable to groundwater, which are listed in Appendix A, Volume I of the Water DSA.

6.4.2.3 Long-Term Effectiveness and Permanence

This alternative permanently removes contaminants from the aquifer through extraction and treatment of groundwater at two different locations. Groundwater from the Basins C and F Plume is captured near the source through an expansion of the already existing and operating Basin F Groundwater IRA. Groundwater contaminants are permanently removed from the Basins C and F plumes through air stripping and GAC adsorption. Contaminants in the air stripper emissions are treated with vapor-phase GAC adsorption. The NBCS also removes contaminants permanently from the aquifer through treatment with GAC.

The extraction and treatment systems continue to operate until contaminant concentrations in the NBCS influent are below PRGs, at which time the systems are turned off. Since the extraction well system relies on natural groundwater gradients and flow to capture contaminants, it is anticipated that this will not occur for 100 or more years.

It should be noted that although contaminants are removed more rapidly by this alternative than by Alternative NC-2, additional contamination may leach into the groundwater from the soil in the unsaturated zone or may desorb into the groundwater from soil in the saturated zone. Therefore, contaminant toxicity and mobility may only decrease very slowly since the contaminants are removed by the treatment system at the same time as they are partially replenished from the environment.

6.4.2.4 Reduction of TMV

This alternative reduces contaminant TMV to a greater extent than does the currently operating Basin F Groundwater/Basin A Neck IRAs. Toxicity of the groundwater is reduced when contaminants are irreversibly removed from the water through GAC adsorption or air stripping. Contaminants in the air emissions from the air stripper are irreversibly removed with vapor-phase GAC. Both the vapor-phase and liquid-phase carbon are thermally regenerated off post.

Mobility of contaminated groundwater is decreased on post when groundwater from the Basins C and F Plume is intercepted and extracted closer to the source of contamination than at the NBCS. Extracting groundwater closer to the source prevents contaminants from dispersing and diluting through the aquifer and adsorbing to the soils, possibly desorbing later as groundwater migrates to the NBCS. Mobility of contaminated groundwater off post is also decreased through operation of the NBCS. As treatment continues, the volume of contaminated water is reduced.

6.4.2.5 Short-Term Effectiveness

Operation of this alternative has minimal negative impact on the environment, the surrounding community, and workers. The only construction required is the installation of extraction wells at the Basins C and F Plume and piping to the Basin A Neck IRA treatment plant. These types of activities have been undertaken in the past with minimal impact on the environment and community. Because this alternative uses the existing Basin A Neck IRA and NBCS for treatment and recharge, there are no additional impacts once the new extraction system is operational.

A potential exists for workers to be exposed to hazardous conditions during construction of the wells and piping; however, this is addressed by the health and safety plan for the remedial construction.

6.4.2.6 Implementability

This alternative is both technically and administratively feasible. Extraction systems, transport systems, reinjection systems, GAC adsorption, and air stripping are demonstrated, reliable, and available technologies already in use at RMA. The treatment plants at the NBCS and Basin A Neck IRA are already in place and operating, so very little, if any, additional training is needed for the plant personnel. All activities take place on post and are in accordance with the FFA.

6.4.2.7 Costs

The capital cost for this system is $869,000, and annual O&M costs are $2,740,000. The present worth cost is $44,400,000. A summary of the costs for this alternative is presented in Appendix A, Table A3-5.

6.5 ALTERNATIVE NC-3/NT-4: INTERCEPTION, OXIDATION

This alternative is similar to Alternative NC-3/NT-3 except that the groundwater, extracted from the Basins C and F Plume using the expanded extraction system (which incorporates the Basin F Groundwater IRA), is treated in an oxidation reactor at the location of the Basin A Neck IRA

treatment system. Table 6.4-1 presents the estimated chemical influent concentrations contributed by the Basins C and F Plume intercept system.

6.5.1 Description of Alternative

6.5.1.1 Extraction/Reinjection

The extraction and reinjection systems for this alternative are exactly the same as those used for Alternative NC-3/NT-3(Section 6.4.1.1). Figure 6.4-1 presents a schematic of this alternative, and Section 6.3.1.1 a description of the extraction and injection systems and water quality.

6.5.1.2 Treatment

Groundwater from the Basins C and F Plume is not treated by the air stripper or the GAC adsorber at the Basin F Groundwater IRA and the Basin A Neck IRA treatment facility. Instead, an ultraviolet light (UV)/hydrogen peroxide oxidation reactor is installed in the Basin A Neck IRA treatment facility to remove the organics from the Basins C and F Plume groundwater. The existing support systems—including the collection tanks, filters, pumps, wiring, and other equipment—are incorporated as needed. Figure 6.5-1 is a process flow diagram for this system.

The existing collection tank is used to collect the extracted water. Hydrogen peroxide is injected into the water stream that is taken from the collection tank and the water passes through a multimedia filter to remove potential iron and manganese precipitation caused by the addition of the hydrogen peroxide. The water then enters the oxidation reactor, where organic compounds are largely destroyed. The oxidation reactor uses UV light and hydrogen peroxide to break down the target organic compounds, primarily chloroform, methylene chloride, diisopropylmethyl phosphonate (DIMP), and atrazine. The reactor has a retention time of 10 minutes and destroys approximately 95 percent of the contaminants. After treatment, the water is pumped through another multimedia filter to the existing effluent collection tank.

6.5.1.3 Sidestreams

Sidestreams generated by this alternative consist of backwash water from the two multimedia filters located on either side of the oxidation reactor. The backwash water flows to a settling tank and sediments are drummed and landfilled while the remaining water is sent to the CERCLA Wastewater Treatment Plant.

6.5.2 Analysis of Alternative

6.5.2.1 Overall Protection of Human Health and the Environment

Human health and the environment are protected off post by operation of the NBCS, which captures and treats groundwater in the Basins C and F and North Plants Plumes before it migrates across the RMA boundary, thereby minimizing the risk for potential exposure to contaminated groundwater.

Human health is protected on post by the FFA, which prohibits the use of RMA groundwater as potable water. The environment is also protected on post because contaminated groundwater is extracted and piped to the existing Basin A Neck IRA treatment facility where the contaminants are irreversibly destroyed with oxidation. Extracting contaminated groundwater from the Basins C and F Plume upgradient of the NBCS reduces the potential for this contamination to spread on post before it migrates across the boundary. Although the Basin F Groundwater IRA already intercepts, extracts, and treats contaminated groundwater, the proposed system intercepts groundwater over a larger area and treats a larger volume of groundwater. The Basin F Groundwater IRA extraction well is already operating at this location and groundwater is treated at the Basin A Neck IRA. Operation of the NBCS reduces contaminant concentrations in the water to acceptable levels before it moves off post.

6.5.2.2 Compliance with ARARs

This alternative is in compliance with all potential action-specific ARARs listed in the Technology Description Volume, Appendix A, including those related to the extraction systems and air emission controls, because it only expands an existing extraction well system and treats groundwater with an existing treatment system, both of which comply with these ARARs. The

treatment system also complies with all potential chemical-specific ARARs listed in Appendix A of the Water DSA and the FFA so long as PRGs are achieved at the RMA boundary through continued operation of the NBCS. The NBCS and the expanded Basins C and F extraction well system comply with all potential location-specific ARARs applicable to groundwater, which are listed in Appendix A, Volume I of the Water DSA.

6.5.2.3 Long-Term Effectiveness and Permanence

This alternative permanently removes contaminants from the aquifer through extraction and treatment of groundwater at two different locations. Groundwater from the Basins C and F Plume is captured near the source through an expansion of the already existing and operating Basin F Groundwater IRA. This increases the mass of contamination that can be removed and may also reduce future loading on the NBCS. Groundwater contaminants are permanently removed from the Basins C and F groundwater and destroyed with UV/hydrogen peroxide oxidation. The NBCS also removes contaminants permanently from the aquifer through treatment with GAC.

The extraction and treatment systems continue to operate until contaminant concentrations in the NBCS influent are below PRGs, at which time the systems are turned off. Since the intercept system relies on natural groundwater gradients and flow to capture contaminants, it is anticipated that this will not occur for 100 or more years.

It should be noted that although contaminants are removed more rapidly by this alternative than by Alternative NC-2, additional contamination may leach into the groundwater from the soil in the unsaturated zone or may desorb into the groundwater from soil in the saturated zone. Therefore, contaminant toxicity and mobility may only decrease very slowly since contaminants are removed by the treatment system at the same time as they are partially replenished from the environment.

6.5.2.4 Reduction of TMV

This alternative reduces contaminant TMV to a greater extent than does the currently operating Basin F Groundwater/Basin A Neck IRAs. Toxicity of the groundwater is reduced when contaminants are irreversibly destroyed by oxidation.

Mobility of contaminated groundwater is decreased on post because groundwater from the Basins C and F Plume is intercepted and extracted closer to the source of contamination than at the NBCS. Extracting groundwater closer to the source prevents contaminants from dispersing and diluting through the aquifer and adsorbing to the soils, possibly desorbing later as groundwater migrates to the NBCS. Mobility of contaminated groundwater off post is also decreased through operation of the NBCS. As treatment continues, the volume of contaminated water is reduced.

6.5.2.5 Short-Term Effectiveness

Operation of this alternative has minimal negative impact on the environment, the surrounding community, and workers. The only construction required is the installation of extraction wells at the existing Basin F Groundwater IRA, piping to the Basin A Neck IRA treatment plant, and installation of a small oxidation unit. These types of activities have been undertaken in the past with minimal impact on the environment and community. Because this alternative uses the NBCS and the existing Basin A Neck IRA building and reinjection system for treatment and recharge, there are no additional impacts once the new extraction system is operational.

A potential exists for workers to be exposed to hazardous conditions during construction of the wells and piping; however, this is addressed by the on-post health and safety plan for the remedial construction.

6.5.2.6 Implementability

This alternative is both technically and administratively feasible. Extraction systems, transport systems, and reinjection systems are demonstrated, reliable, and available technologies already

in use at RMA. Advanced oxidation processes, such as UV/hydrogen peroxide oxidation, are innovative technologies and treatability studies must be conducted before a design can be finalized (Technology Description Volume, Section 14.1). The treatment plant at the NBCS is already operational, so no additional training is needed for the plant personnel. Some training may be required for personnel operating the oxidation system.

6.5.2.7 Costs

The capital cost for this system is $1,860,000, and annual O&M costs are $2,820,000. The present worth cost is $46,800,000. A summary of the costs is presented in Appendix A, Table A3-5.

6.6 ALTERNATIVE NC-6: CLAY/SOIL CAP

This alternative consists of installation of a clay/soil cap over the Basins C and F Plume and continued operation of the existing Basin F Groundwater IRA. No additional treatment is needed beyond continued operation of the NBCS and the Basin F Groundwater IRA.

6.6.1 Description of Alternative

6.6.1.1 Extraction/Reinjection

Alternative NC-6 provides for the installation of a clay/soil cap over the Basins C and F Plume to reduce leaching of contaminants and groundwater recharge in the source area (Figure 6.6-1). (A clay/soil cap is also being considered for the remedial alternative of soils for this area.) This alternative also includes continued operation of the NBCS and the Basin F Groundwater IRA. This alternative is easily implemented and the equipment is readily available. However, Alternative NC-6 is only cost effective for groundwater if capping is retained as the preferred alternative for soils. The installation of a slurry wall was included in the Water DSA, but is not included in the present alternative because the estimated effectiveness of the cap and the little added benefit of the slurry wall. This alternative minimizes downward migration of contaminants from contaminated soils to the groundwater and, in the long term, reduces loading at the NBCS. As a result of reduced recharge, water levels decline beneath the sources and groundwater flows

primarily in bedrock rather than in alluvium. The volume and velocity of groundwater flow toward the NBCS is reduced somewhat. The clay/soil cap requires periodic maintenance.

Under this alternative, a low-permeability clay/soil cap, with proper grading and drainage to minimize infiltration, is constructed across the top of the area. The clay cap consists of a 2-ft layer of compacted low-permeability soil, a 1-ft biota barrier of cobbles, and a 4-ft soil/vegetation layer that includes 6 inches of top soil. The construction timing and methods are coordinated with the soil alternatives for Basins C and F since the preferred alternative for former Basin F and the Basin F Wastepile is capping.

Groundwater-quality and water-level data from a monitoring network of existing plume evaluation monitoring wells are used to evaluate the effectiveness of this alternative. Monitoring wells located both around and within the capped area are monitored. A groundwater divide underlies this area. Groundwater flows north from one side of the divide and west or northwest from the other side. Lowering of water levels may cause a shift in the divide and affect migration directions in the Basins C and F area. Monitoring water levels within and outside of the capped area allows for the evaluation of possible changes in the direction of groundwater migration.

This alternative requires no additional recharge capacity for trenches on the NBCS or the Basin A Neck IRA. Alternative NC-6 is only cost effective if a similar capping scenario is retained as the soils remedial alternative. Since water levels in the area decline due to lack of recharge, contaminant migration occurs primarily in weathered bedrock, resulting in reduced flow and loading at the NBCS.

6.6.1.2 Treatment

The existing treatment systems at the NBCS and the Basin F Groundwater/Basin A Neck IRAs continue to operate. No additional groundwater is extracted, so new treatment systems are not required.

6.6.1.3 Sidestreams

This alternative does not generate any new sidestreams.

6.6.2 Analysis of Alternative

6.6.2.1 Overall Protection of Human Health and the Environment

This alternative provides protection of human health and the environment by removing contaminated groundwater on post and treating it at the NBCS and Basin F Groundwater/Basin A Neck IRAs. Treatment of groundwater at these facilities reduces the risk for potential exposure off post by removing chloroform and other contaminants from the groundwater before it leaves the RMA boundary. Extracting contaminated groundwater at the Basin F Groundwater IRA upgradient of the NBCS reduces the migration of contamination from Basin F toward the boundary. Operation of the NBCS reduces contaminant concentrations in the water to acceptable levels at the boundary.

In addition, installation of a cap over Basins C and F reduces recharge under the cap and thereby reduces leaching of additional contaminants into the groundwater. This is protective of the environment on post because it prevents additional contaminants from being leached into the groundwater.

6.6.2.2 Compliance with ARARs

This alternative is in compliance with all potential action-specific ARARs listed in the Technology Description Volume, Appendix A, including those related to the extraction systems and air emission controls, because it uses an existing system that complies with these ARARs. Installation of the clay/soil cap complies with potential air emission ARARs regarding particulate and opacity concerns and emissions from diesel vehicles. The existing system also complies with all chemical-specific ARARs listed in Appendix A, Volume I of the Water DSA and the FFA so long as PRGs are achieved at the RMA boundary through continued operation of the NBCS. The NBCS provides compliance with all potential location-specific ARARs applicable to groundwater, which are listed in Appendix A, Volume I of the Water DSA.

6.6.2.3 Long-Term Effectiveness and Permanence

This alternative removes contaminants permanently from the aquifer through treatment with GAC and reduces the mass of contamination that may leach into the groundwater under the Basins C and F cap. The extraction and treatment systems continue to operate until contaminant concentrations in the NBCS influent are below PRGs, at which time the systems are turned off. Since the intercept system relies on natural groundwater gradients and flow to capture contaminants, it is anticipated that this will not occur for 100 or more years for the Basin F Groundwater IRA or the NBCS. When the systems are turned off, the potential for off-post exposure to contaminated groundwater will have been reduced to acceptable levels.

It should be noted that although contaminants are removed by this alternative and the potential for future leaching into the aquifer is reduced, thus reducing the total mass of contamination in the aquifer, additional contamination may leach into the groundwater from the soil in the unsaturated zone that is not covered by the cap or may desorb into the groundwater from soil in the saturated zone. Therefore, contaminant toxicity and mobility may only decrease slowly since contaminants are removed by the treatment system at the same time as they are partially replenished from the environment.

6.6.2.4 Reduction of TMV

Contaminant TMV is reduced by this alternative. Toxicity of the groundwater is reduced when contaminants are adsorbed to the GAC during treatment. The carbon is thermally regenerated off post.

Mobility of contaminants is decreased on post by reduced recharge under the cap and a resulting reduction in desorption of contaminants from the soil above the water table. If the cap is not installed, the contaminants become more dispersed and diluted in the groundwater as it migrates to the NBCS. Mobility of contaminated groundwater off post is also decreased through operation of the NBCS.

The cap reduces the volume of contaminated water by reducing the amount of water infiltrating into the ground.

6.6.2.5 Short-Term Effectiveness

Some short-term impacts to the environment and community may exist during construction of the cap; however, these can be minimized through dust and vapor emissions controls. Once the cap is in place, operation of this alternative has minimal negative impact on the environment, surrounding communities, and workers. Because this alternative uses the existing NBCS and Basin F Groundwater/Basin A Neck IRAs for treatment and recharge, there are no additional impacts once the new cap is in place.

A potential exists for workers to be exposed to hazardous conditions during construction of the wells and piping; however, this is addressed by the health and safety plan for the remedial construction.

6.6.2.6 Implementability

This alternative is both technically and administratively feasible. Clay/soil caps and GAC adsorption are both demonstrated, reliable, and available technologies already in use at RMA. The treatment plants are already in place and operating, so very little additional training, if any, is needed for the plant personnel. All activities take place on post and are in accordance with the FFA.

6.6.2.7 Costs

The capital cost for this system is $49,600,000, and annual O&M costs are $2,600,000. The present worth cost is $90,900,000. A summary of costs is presented in Appendix A, Table A3-6.

Table 6.0-1 Comparative Analysis of Alternatives: North Boundary Plume Group

Criteria	ALT NC-1 No Action	ALT NC-2 Continued Existing Action
1. Overall protection of human health and the environment	Does not meet RAOs at the boundary; contamination free to migrate off post	Reduces potential exposure to acceptable levels
2. Compliance with ARARs –Action-specific –Location-specific –Chemical-specific –Criteria, advisories, and guidance	Does not comply with chemical-specific ARARs and FFA; complies with location-specific ARARs; action-specific ARARs do not apply	Complies with action-, location-, and chemical-specific ARARs
3. Long-term effectiveness and permanence –Magnitude and residual risks –Adequacy and reliability of controls	Potential for off-post exposure due to contaminant migration Existing controls removed	NBCS minimizes potential for off-post exposure Adequate existing controls, but long-term maintenance required
4. Reduction of TMV through treatment –Treatment process used and materials treated –Degree and quantity of TMV reduction –Irreversibility of TMV reduction	No treatment undertaken TMV reduced over time by natural attenuation	Contaminants removed by GAC adsorption at NBCS and air stripping and GAC adsorption at the Basin A and Basin F Groundwater/Basin A Neck IRAs treatment facility 300 gpm removed and treated at NBCS; 1-4 gpm at Basin F Groundwater IRA Contaminants irreversibly transferred to GAC, which requires regeneration
5. Short-term effectiveness –Protection of workers during remedial action –Protection of community during remedial action –Environmental impacts of remedial action –Time until RAOs are achieved	Minimal negative impact on the environment, surrounding community, and workers Contamination free to migrate off post Natural attenuation ongoing, but does not meet RAOs	Minimal negative impact on the environment, surrounding community, and workers RAOs achieved; may require operation for more than 100 years
6. Implementability –Technical feasibility –Administrative feasibility –Availability of services and materials	Technically feasible Not administratively feasible: does not comply with FFA	Technically and administratively feasible Already operational
7. Costs		
–Capital Cost	$166,000	$0
–Annual O&M Cost	$75,000	$2,590,000
–Present Worth	$1,360,000	$41,200,000

ARAR	Applicable or relevant and appropriate requirement
COC	Contaminant of concern
FFA	Federal Facility Agreement
GAC	Granular activated carbon
IRA	Interim Response Action
NBCS	North Boundary Containment System
O&M	Operations and maintenance
RAO	Remedial action objective
TMV	Toxicity, mobility, or volume

Table 6.0-1 Comparative Analysis of Alternatives: North Boundary Plume Group

Criteria	ALT NC-3/NT-2 Interception,Treatment at NBCS	ALT NC-3/NT-3 Interception, Treatment at Basin A Neck IRA
1. Overall protection of human health and the environment	Reduces potential exposure to acceptable levels	Reduces potential exposure to acceptable levels
2. Compliance with ARARs –Action-specific –Location-specific –Chemical-specific –Criteria, advisories, and guidance	Complies with action-, location-, and chemical-specific ARARs	Complies with action-, location-, and chemical-specific ARARs
3. Long-term effectiveness and permanence –Magnitude and residual risks –Adequacy and reliability of controls	Reduces potential for off-post exposure COCs intercepted near source and at NBCS, treated at NBCS Monitoring program continues	Reduces potential for off-post exposure; Contaminants intercepted near source and at NBCS and treated at Basin F Groundwater/Basin A Neck IRA treatment facility and NBCS Monitoring program continues
4. Reduction of TMV through treatment –Treatment process used and materials treated –Degree and quantity of TMV reduction –Irreversibility of TMV reduction	Contaminants removed by GAC adsorption; capture system close to source reduces migration through the aquifer 6 gpm from Basins C and F Plume and 300 gpm from NBCS removed and treated Contaminants irreversibly transferred to GAC which requires regeneration	Contaminants removed by GAC adsorption at NBCS; Basins C and F Plume treated with air stripping and GAC adsorption at Basin F Groundwater/Basin A Neck IRA treatment facility; capture system close to source reduces migration through the aquifer 6 gpm from Basins C and F Plume and 300 gpm from NBCS removed and treated; contaminants irreversibly transferred to vapor- and liquid-phase GAC, which requires regeneration; lower GAC consumption than NT-2
5. Short-term effectiveness –Protection of workers during remedial action –Protection of community during remedial action –Environmental impacts of remedial action –Time until RAOs are achieved	Minimal negative impact on the environment, surrounding community, and workers RAOs achieved; may require operation for more than 100 years	Minimal negative impact on the environment, surrounding community, and workers RAOs achieved; may require operation for more than 100 years

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ARAR	Applicable or relevant and appropriate requirement
COC	Contaminant of concern
FFA	Federal Facility Agreement
GAC	Granular activated carbon
IRA	Interim Response Action
NBCS	North Boundary Containment System
O&M	Operations and maintenance
RAO	Remedial action objective
TMV	Toxicity, mobility, or volume

Criteria	ALT NC-3/NT-2 Interception,Treatment at NBCS	ALT NC-3/NT-3 Interception, Treatment at Basin A Neck IRA
6. Implementability -Technical feasibility -Administrative feasibility -Availability of services and materials	Technically feasible: demonstrated, available technologies, reliable equipment, and experienced operators Administratively feasible	Technically feasible: demonstrated, available technologies, reliable equipment, and experienced operators Administratively feasible
7. Cost		
-Capital Cost	$764,000	$869,000
-Annual O&M Cost	$2,710,000	$2,740,000
-Present Worth	$43,900,000	$44,400,000

ARAR	Applicable or relevant and appropriate requirement		
COC	Contaminant of concern	NBCS	North Boundary Containment System
FFA	Federal Facility Agreement	O&M	Operations and maintenance
GAC	Granular activated carbon	RAO	Remedial action objective
IRA	Interim Response Action	TMV	Toxicity, mobility, or volume

Table 6.0-1 Comparative Analysis of Alternatives: North Boundary Plume Group

Criteria	ALT NC-3/NT-4 Interception, Oxidation	ALT NC-6 Clay/Soil Cap
1. Overall protection of human health and the environment	Reduces potential exposure to acceptable levels	Reduces potential exposure to acceptable levels
2. Compliance with ARARs –Action-specific –Location-specific –Chemical-specific –Criteria, advisories, and guidance	Complies with action-, location-, and chemical-specific ARARs	Complies with action-, location-, and chemical-specific ARARs
3. Long-term effectiveness and permanence –Magnitude and residual risks –Adequacy and reliability of controls	Reduces potential for off-post exposure COCs intercepted by expanded extraction system near source at Basins C and F and treated at Basin A Neck IRA facility; and intercepted and treated at NBCS Monitoring program continues	NBCS minimizes potential for off-post exposure Contaminants intercepted by Basin F groundwater IRA and treated at Basin A Neck IRA and intercepted and treated at NBCS Monitoring program continues Cap requires habitat restrictions to burrowing animals Cap reduces leaching by reduced recharge from surface
4. Reduction of TMV through treatment –Treatment process used and materials treated –Degree and quantity of TMV reduction –Irreversibility of TMV reduction	Contaminants removed by GAC adsorption at NBCS; Basins C and F water treated with oxidation; capture system close to source reduces migration through the aquifer 6 gpm from Basins C and F Plume and 300 gpm from NBCS removed and treated; contaminants destroyed by oxidation or transferred to GAC at NBCS, which requires regeneration; lower GAC consumption than NT-2 or NT-3	TMV reduction through reduced leachate generation and continued NBCS operation of the Basin F Groundwater and Basin A Neck IRAs Damage to cap would allow remobilization of contaminants 6 gpm from Basins C and F Plume and 300 gpm from NBCS removed and treated Contaminants at NBCS transferred to GAC, which requires regeneration; lower GAC consumption than NT-2, NT-3, or NT-4

ARAR	Applicable or relevant and appropriate requirement		
COC	Contaminant of concern	NBCS	North Boundary Containment System
FFA	Federal Facility Agreement	O&M	Operations and maintenance
GAC	Granular activated carbon	RAO	Remedial action objective
IRA	Interim Response Action	TMV	Toxicity, mobility, or volume

Criteria	ALT NC-3/NT-4 Interception, Oxidation	ALT NC-6 Clay/Soil Cap
5. Short-term effectiveness –Protection of workers during remedial action –Protection of community during remedial action –Environmental impacts of remedial action –Time until RAOs are achieved	Minimal negative impact on the environment, surrounding community, and worker protection RAOs achieved; may require operation for more than 100 years	Worker exposure controls during cap construction; dust and vapor controls for community protection RAOs achieved; may require operation for more than 100 years
6. Implementability –Technical feasibility –Administrative feasibility –Availability of services and materials	Technically feasible: GAC adsorption is demonstrated, available technology, with reliable equipment, and experienced operators; advanced oxidation process is innovative, requires more oversight and additional operator training Administratively feasible	Technically feasible: demonstrated, available technologies; reliable equipment; and experienced operators Administratively feasible
7. Cost		
–Capital Cost	$1,860,000	$49,600,000
–Annual O&M Cost	$2,820,000	$2,600,000
–Present Worth	$46,800,000	$90,900,000

ARAR	Applicable or relevant and appropriate requirement		
COC	Contaminant of concern	NBCS	North Boundary Containment System
FFA	Federal Facility Agreement	O&M	Operations and maintenance
GAC	Granular activated carbon	RAO	Remedial action objective
IRA	Interim Response Action	TMV	Toxicity, mobility, or volume

Table 6.3-1 North Boundary Plume Group Estimated Influent Concentrations

Chemical Group / Compound	Estimated Influent Concentration (ug/l)	Target Effluent Concentration (ug/l)
Volatile Halogenated Organic Compounds (VHOs)		
1,2-Dichloroethane	0.64	10
1,1-Dichloroethylene	0.02	14
1,1,1-Trichloroethane	0.01	400
1,1,2-Trichloroethane	0.01	6
Carbon tetrachloride	0.84	10
Chlorobenzene	0.02	50
Chloroform	4.3	30
Methylene chloride	2.8	10
Tetrachloroethylene	2.5	10
Trichloroethylene	0.47	10
Volatile Hydrocarbon Compounds (VHCs)		
Dicyclopentadiene	5.3	92
Volatile Aromatic Organic Compounds (VAOs)		
Benzene	0.70	10
Ethylbenzene	0.02	1360
o-and p-Xylene	0.04	20000
Toluene	0.13	2000
Organosulfur Compounds, Mustard Agent Related (OSCMs)		
1,4-Oxathiane	0.18	320
Dithiane	1.3	36
Organosulfur Compounds, Herbicide Related (OSCHs)		
Chlorophenylmethyl sulfide	0.30	60
Chlorophenylmethyl sulfone	6.3	72
Chlorophenylmethyl sulfoxide	6.3	72
Organophosphorous Compounds, GB-Agent Related (OPHGBs)		
Diisopropylmethyl phosphonate	12.	1200
Isopropylmethyl phosphonic acid	130.	1400
Organophosphorus Compounds, Pesticide Related (OPHPs)		
Atrazine	3.2	8.06
Malathion	0.27	200
Dibromochloropropane (DBCP)		
Dibromochloropropane	0.11	0.40

Table 6.3-1 North Boundary Plume Group Estimated Influent Concentrations

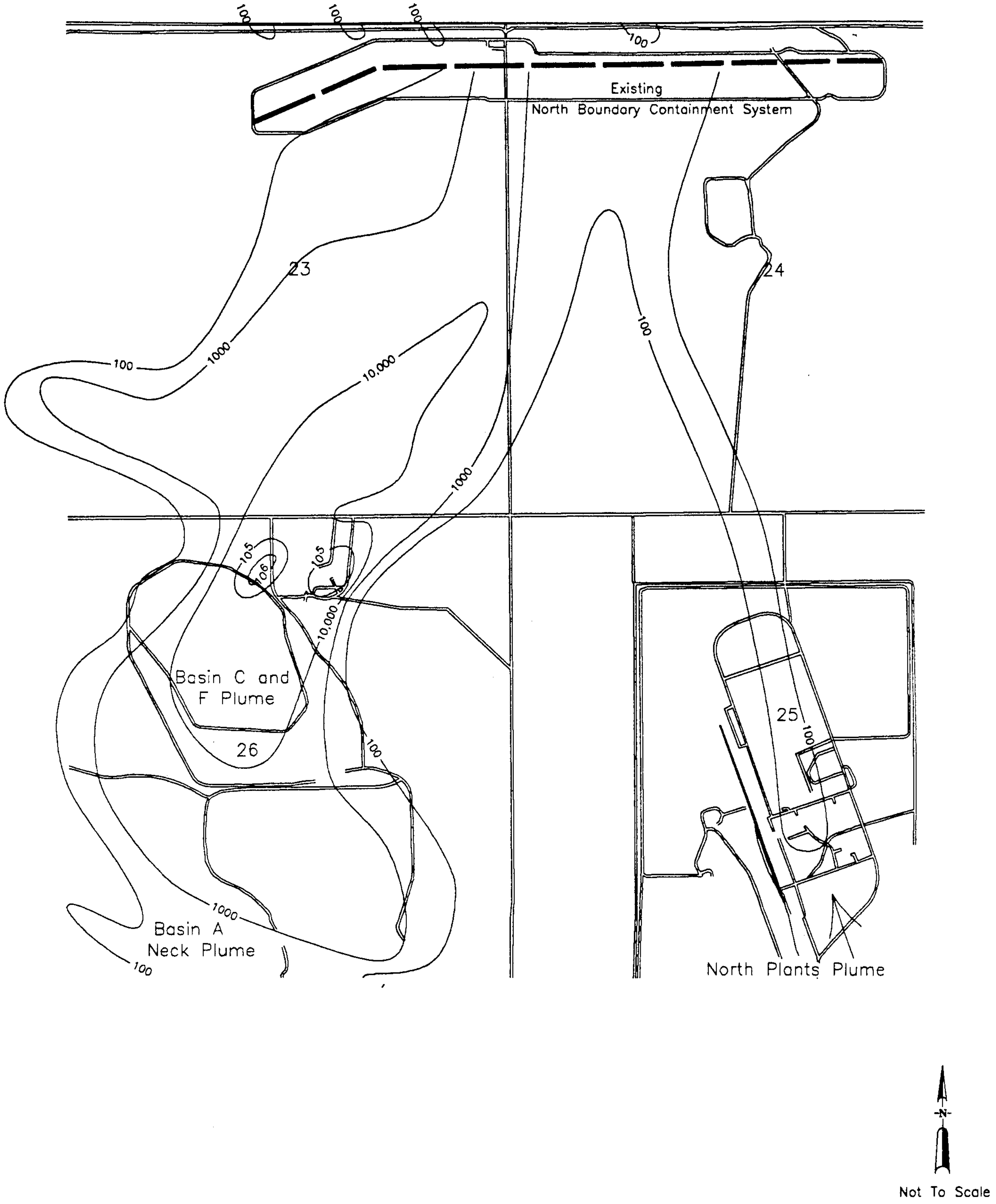
Chemical Group / Compound	Estimated Influent Concentration (ug/l)	Target Effluent Concentration (ug/l)
Semivolatile Halogenated Organic Compounds (SHOs)		
Hexachlorocylopentadiene	0.06	0.46
Organochlorine Pesticides (OCPs)		
Aldrin	0.03	0.10
Chlordane	0.06	4
PPDDE	0.03	0.11
PPDDT	0.06	0.20
Dieldrin	0.06	0.10
Endrin	0.05	0.40
Isodrin	0.03	0.12
Arsenic		
Arsenic	1.5	100
Mercury		
Mercury	0.07	4
ICP Metals		
Cadmium	0.08	10
Chromium	0.32	200
Lead	7.1	100

Table 6.4-1 NC-3 Basin C & F Intercept System Estimated Influent Concentrations

Chemical Group / Compound	Estimated Influent Concentration (ug/l)	Target Effluent Concentration (ug/l)
Volatile Halogenated Organic Compounds (VHOs)		
1,2-Dichloroethane	2.0	10
1,1-Dichloroethylene	0.93	14
1,1,1-Trichloroethane	0.56	400
1,1,2-Trichloroethane	0.59	6
Carbon tetrachloride	0.75	10
Chlorobenzene	0.85	50
Chloroform	81.	30
Methylene chloride	8.1	10
Tetrachloroethylene	6.3	10
Trichloroethylene	7.0	10
Volatile Hydrocarbon Compounds (VHCs)		
Dicyclopentadiene	62.	92
Volatile Aromatic Organic Compounds (VAOs)		
Benzene	8.2	10
Ethylbenzene	1.0	1360
o-and p-Xylene	2.0	20000
Toluene	6.1	2000
Organosulfur Compounds, Mustard Agent Related (OSCMs)		
1,4-Oxathiane	8.7	320
Dithiane	20.	36
Organosulfur Compounds, Herbicide Related (OSCHs)		
Chlorophenylmethyl sulfide	14.	60
Chlorophenylmethyl sulfone	110.	72
Chlorophenylmethyl sulfoxide	15.	72
Organophosphorous Compounds, GB-Agent Related (OPHGBs)		
Diisopropylmethyl phosphonate	390.	1200
Isopropylmethyl phosphonic acid	6100.	1400
Organophosphorus Compounds, Pesticide Related (OPHPs)		
Atrazine	19.	8.06
Malathion	1.0	200
Dibromochloropropane (DBCP)		
Dibromochloropropane	0.38	0.40

Table 6.4-1 NC-3 Basin C & F Intercept System Estimated Influent Concentrations

Chemical Group / Compound	Estimated Influent Concentration (ug/l)	Target Effluent Concentration (ug/l)
Semivolatile Halogenated Organic Compounds (SHOs)		
Hexachlorocylopentadiene	0.19	0.46
Organochlorine Pesticides (OCPs)		
Aldrin	0.13	0.10
Chlordane	0.27	4
PPDDE	0.09	0.11
PPDDT	0.25	0.20
Dieldrin	0.26	0.10
Endrin	0.14	0.40
Isodrin	0.11	0.12
Arsenic		
Arsenic	9.2	100
Mercury		
Mercury	0.13	4
ICP Metals		
Cadmium	3.8	10
Chromium	15.	200
Lead	27.	100



LEGEND

—100— Summed Concentration of organic analytes (Table 3.1–2) in unconfined aquifer (ug/L)

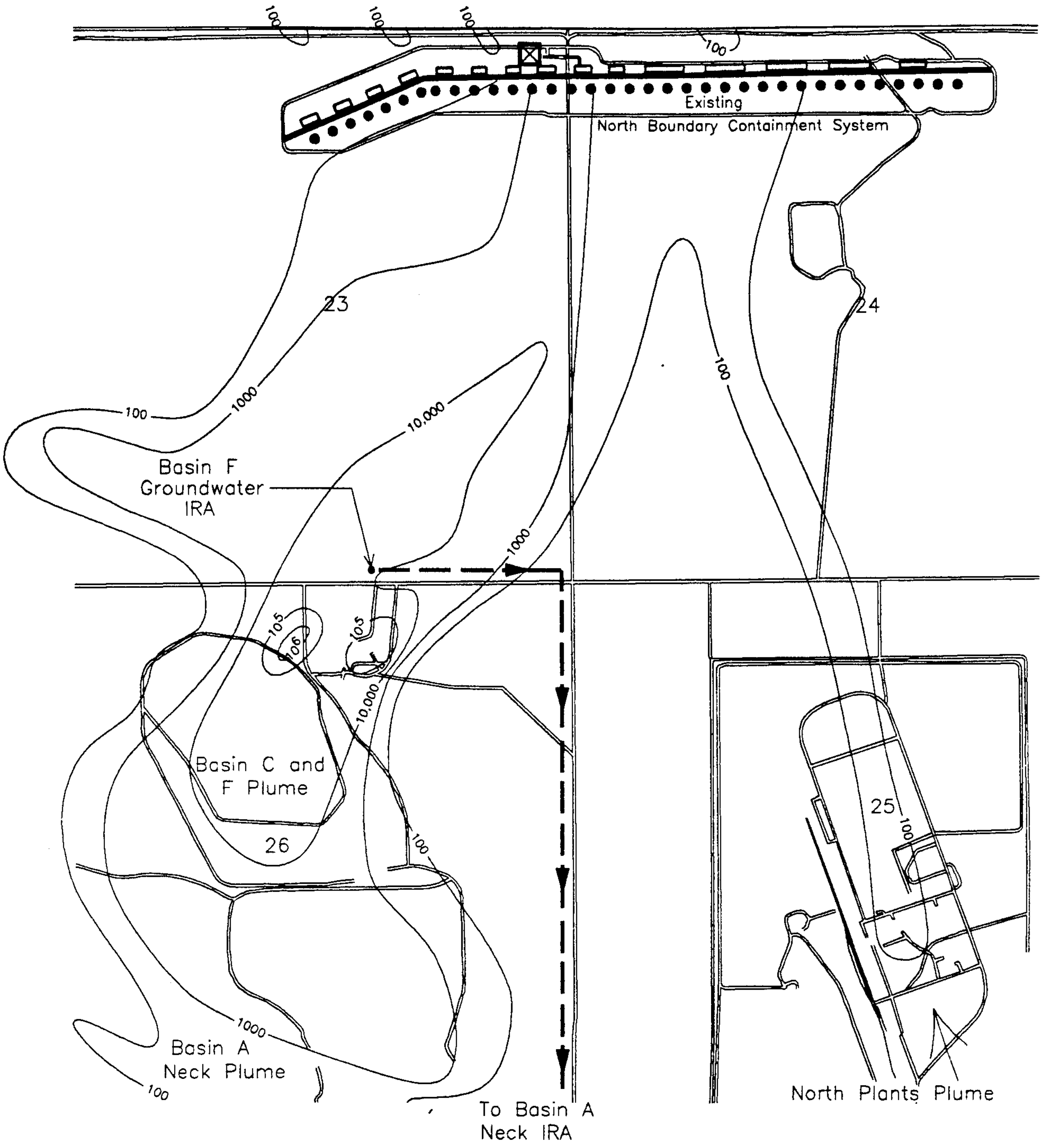
— — Perforated Slurry Wall

SOURCE: Water DSA Plume Map

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 6.1–1
Schematic for North Boundary
Plume Group
Control Alternative NC–1

Prepared by:
EBASCO SERVICES INCORPORATED



N

Not To Scale

LEGEND

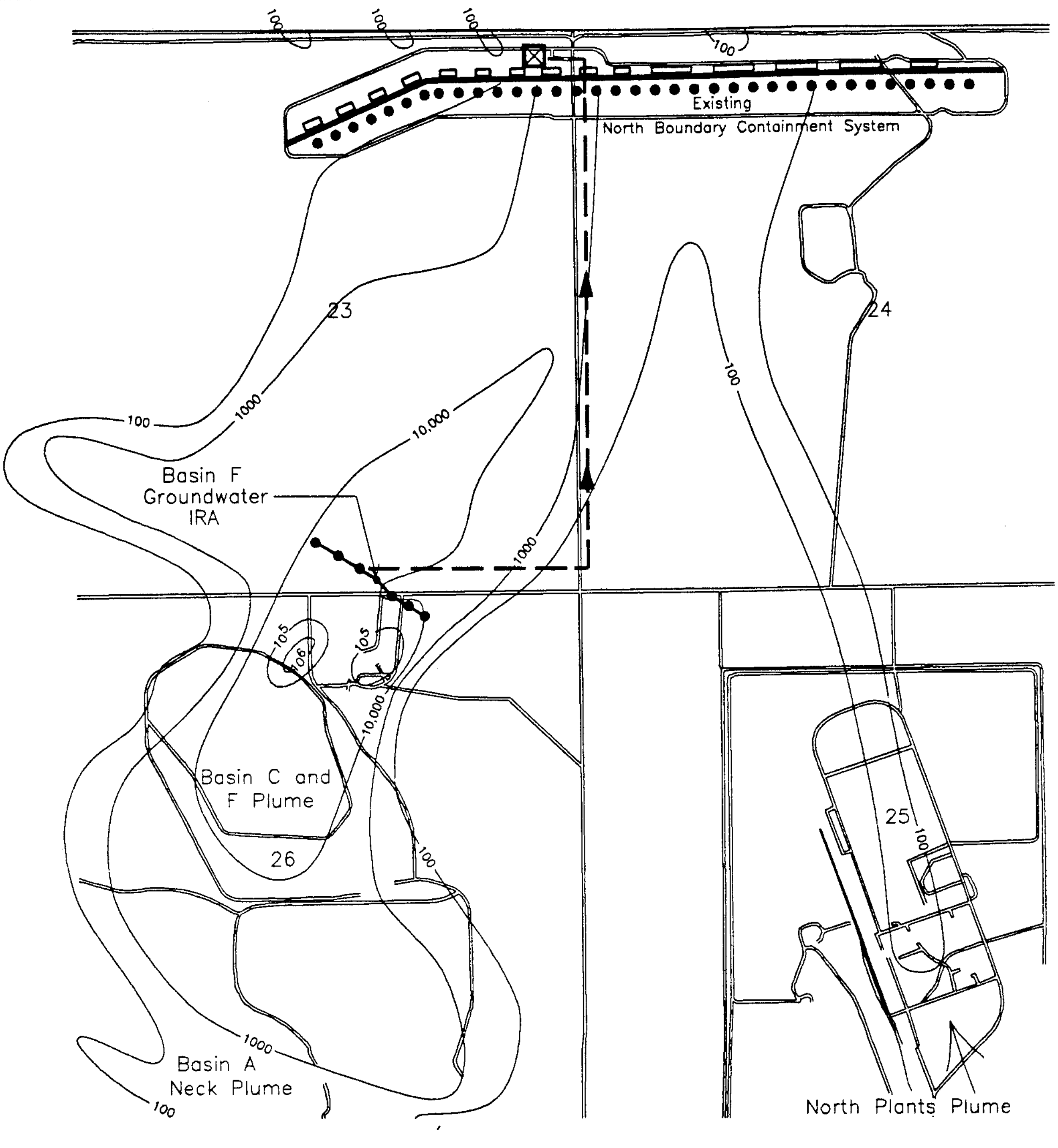
~100~	Summed Concentration of organic analytes (Table 3.1-2) in unconfined aquifer (ug/L)
●	Extraction Well
▭	Recharge Trench
▬	Slurry Wall
– – –	Transport Pipe
☒	Treatment Plant

SOURCE: Water DSA Plume Map

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 6.2-1
Schematic for North Boundary
Plume Group
Control Alternative NC-2

Prepared by:
EBASCO SERVICES INCORPORATED



LEGEND

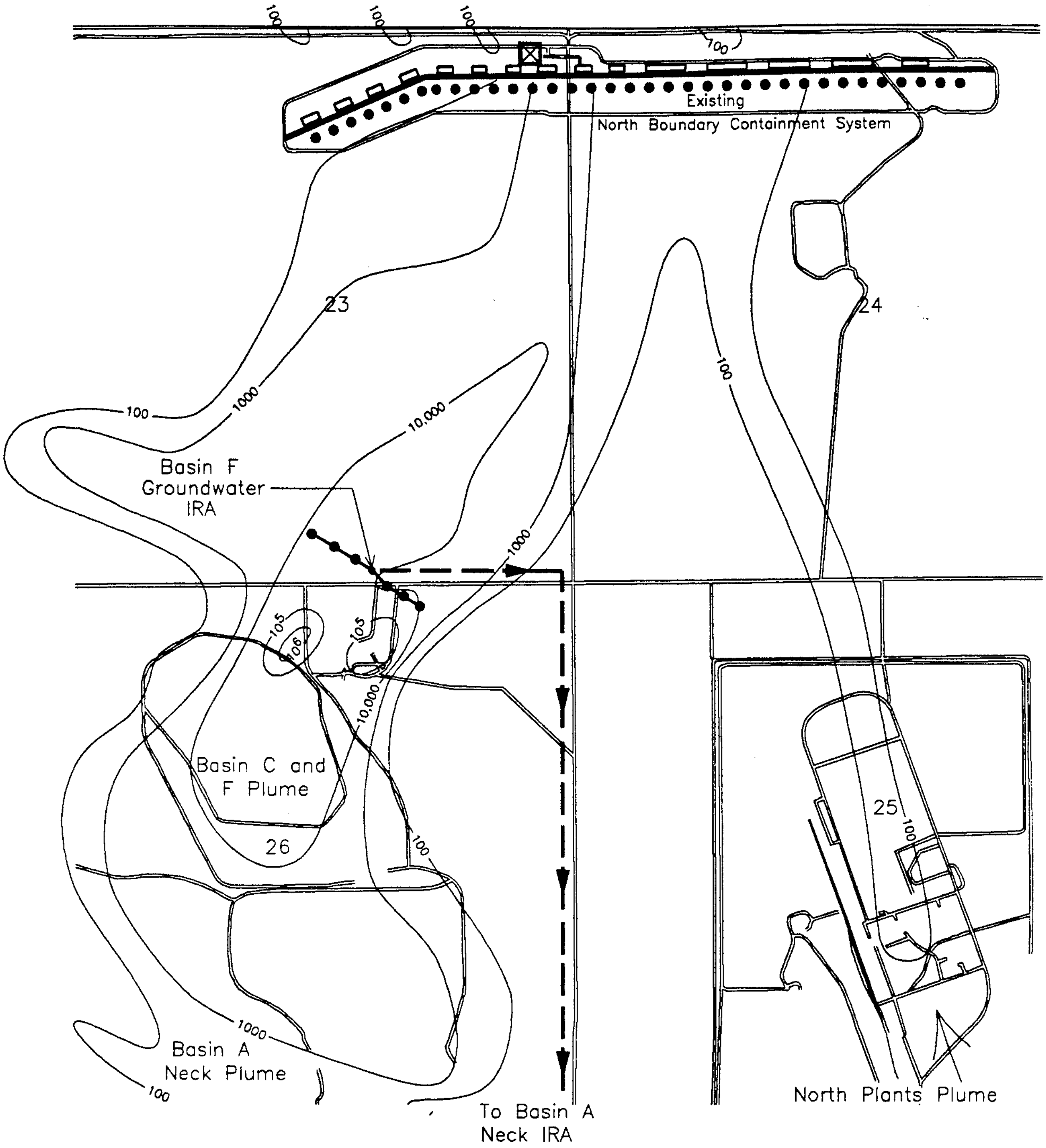
100	Summed Concentration of organic analytes (Table 3.1-2) in unconfined aquifer (ug/L)
●	Extraction Well
▭	Recharge Trench
▬	Slurry Wall
— — —	Transport Pipe
☒	Treatment Plant

SOURCE: Water DSA Plume Map

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 6.3-1
Schematic for North Boundary Plume Group
Control Alternative NC-3/NT-2

Prepared by:
EBASCO SERVICES INCORPORATED



LEGEND

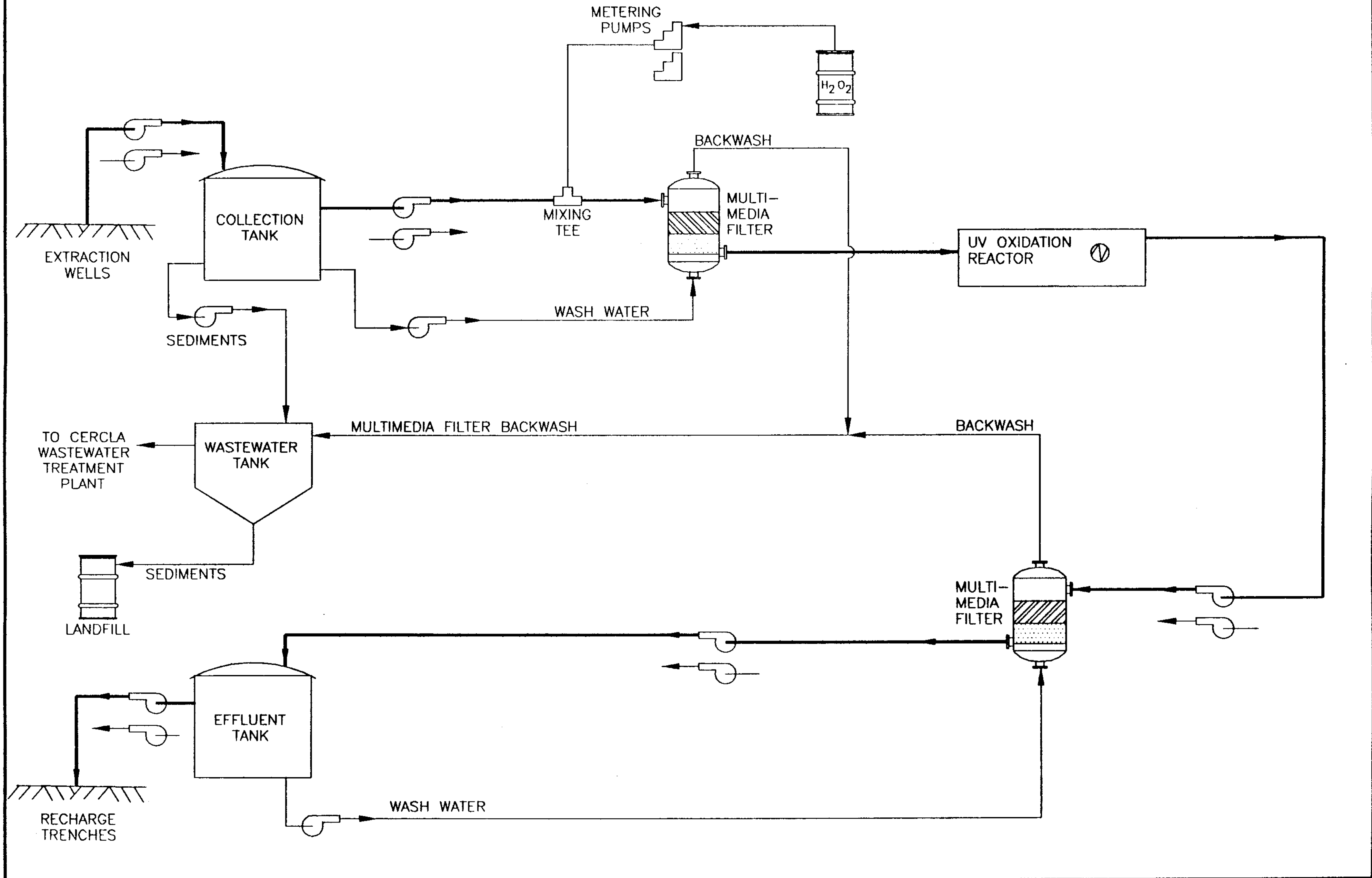
—100—	Summed Concentration of organic analytes (Table 3.1–2) in unconfined aquifer (ug/L)
●	Extraction Well
▭	Recharge Trench
━━━	Slurry Wall
— — —	Transport Pipe
☒	Treatment Plant

SOURCE: Water DSA Plume Map

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 6.4–1
Schematic for North Boundary
Plume Group
Control Alternative NC–3/NT–3,NT–4

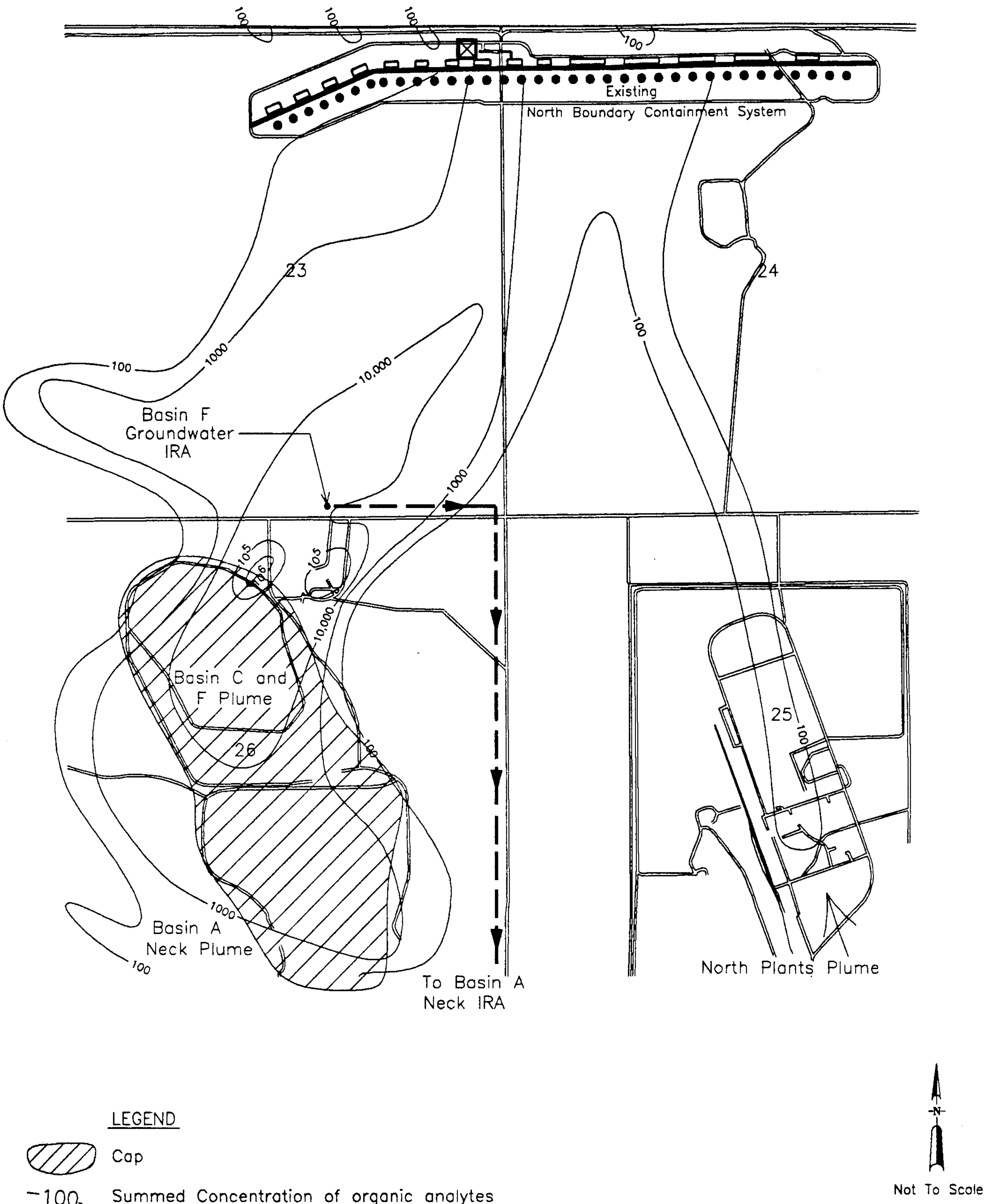
Prepared by:
EBASCO SERVICES INCORPORATED



Prepared for:
Office for the Program Manager
for Rocky Mountain Arsenal

FIGURE 6.5-1
Process Flow Diagram
Treatment Alternative NT-4,
Oxidation

Prepared by:
Ebasco Services Incorporated



LEGEND

▨ Cap

100 Summed Concentration of organic analytes (Table 3.1-2) in unconfined aquifer (ug/L)

● Extraction Well

▭ Recharge Trench

━ Slurry Wall

– – – Transport Pipe

☒ Treatment Plant

SOURCE: Water DSA Plume Map

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 6.6-1
Schematic for North Boundary
Plume Group
Control Alternative NC-6

Prepared by:
EBASCO SERVICES INCORPORATED

7.0 BASIN A PLUME GROUP

Five alternatives were retained for consideration in the Water DAA for the Basin A Plume Group. These alternatives range from no action and continued existing action to three alternatives that include groundwater extraction and treatment or capping. The CERCLA Wastewater Treatment Plant may potentially be modified to treat the Basin A groundwater rather than constructing the treatment systems discussed in this section for this plume group (U.S. Army Corps of Engineers 1991). This depends on the available capacity and planned use as well as the possibility for making modifications (including expansions and changes to continuous operation) to the CERCLA Wastewater Treatment Plant at the time the proposed groundwater treatment begins.

The Basin A Plume Group is made up of the Basin A, South Plants North, and Section 36 Bedrock Ridge Plumes. Contaminants exceeding the PECs in these plumes include chloroform, benzene, tetrachloroethylene, methylene chloride, aldrin, DBCP, and chlordane. These contaminants have only been detected in dissolved form in groundwater; however, if dense nonaqueous phase liquid (DNAPL) is determined to be present in this area, the planned or existing extraction/treatment systems will be modified to include appropriate DNAPL treatment.

One treatment system, the Basin A Neck IRA, currently in place, is removing contamination from the Basin A Plume. This pump-and-treat system, located north of Eighth Avenue and just west of "D" Street, also accepts groundwater from the Basin F Groundwater IRA extraction system. Treatment at the Basin A Neck IRA facility includes air stripping (Basin F groundwater only) and GAC adsorption (combined stream). Two other IRAs, the Shell Trenches and the Lime Settling Basins IRAs, are also in place as source control activities.

Alternatives evaluated for both the Basin A and South Plants Plume Groups that involve construction of a treatment facility will include treatment at a common location, which is referred

to as the Basin A/South Plants combined treatment plant. This plant will house the treatment systems for extracted groundwater from both the Basin A and South Plants Plume Groups.

The following sections provide detailed descriptions and analyses for each of the five alternatives retained from the Water DSA for the Basin A Plume Group. Table 7.0-1 presents a summary of the analyses.

7.1 ALTERNATIVE AC-1: NO ACTION

Under this alternative, all currently operating and planned groundwater IRAs are discontinued. This involves shutting down the Basin A Neck IRA and breaching the existing slurry wall between the extraction wells and the reinjection trenches. The Shell Trenches IRA is not impacted because it is already completed and does not include any groundwater extraction activities. The Lime Settling Basins IRA is also not affected by the No Action alternative. Section 7.2 presents a more detailed discussion of the relevant IRAs.

7.1.1 Description of Alternative

7.1.1.1 Extraction/Reinjection

This alternative specifies that any groundwater controls be discontinued, which primarily impacts the Basin A Neck IRA. This IRA consists of seven extraction wells, a slurry wall barrier, three reinjection trenches, a GAC adsorption system, and an air stripper with off-gas treatment (for groundwater pumped from the Basin F Groundwater IRA). The GAC system operates at 12 to 13 gpm and the air stripper currently operates at approximately 2.5 gpm (James 1993). The No Action alternative requires that this system be shut down and the slurry wall be breached. Perforation of the slurry wall prevents an increase in hydraulic head in the contaminated alluvial aquifer. Dismantling the Basin A Neck IRA treatment structure has been addressed by alternatives evaluated for the No Future Use, Manufacturing History Medium Group in the Structures DAA. Figure 7.1-1 presents the schematic for Alternative AC-1.

The Shell Trenches IRA, located in the southeast corner of Basin A in the area of the Shell Trenches, is not impacted by the No Action alternative. This source control action consists of a vertical slurry wall barrier and a low-permeability cap to reduce the lateral migration of contaminants emanating from the Shell Trenches (MKE 1991). The slurry wall is not destroyed under the No Action alternative because the wall entombs contaminants and does not significantly disrupt the normal flow of groundwater in this area.

The Lime Settling Basins IRA, as planned, includes construction of a subsurface barrier around the basins and the placement of a cover with a vegetative barrier. (WCC 1990). The Army has recently proposed a modification to the final decision document for this IRA. As part of the modification, the slurry wall and groundwater extraction system will not be constructed. Alternative AC-1 does not affect this IRA.

7.1.1.2 Treatment

No treatment is associated with this alternative. Current GAC treatment at the Basin A Neck IRA is discontinued.

7.1.1.3 Sidestreams

No sidestreams are generated by this alternative.

7.1.2 Analysis of Alternative

7.1.2.1 Overall Protection of Human Health and the Environment

The No Action alternative for the Basin A Plume Group allows contaminants to migrate from their Basin A sources toward the RMA boundary. It is, however, assumed that the boundary systems are in operation and capture any contamination reaching the boundary. This alternative is consequently protective of human health and the off-post environment even though it allows the continued migration of contamination on post.

7.1.2.2 Compliance with ARARs

Action-specific ARARs listed in the Technology Description Volume, Appendix A are not relevant if the No Action alternative is chosen. This alternative complies with all potential location- and chemical-specific ARARs and with the FFA so long as the boundary systems continue to reduce contaminant concentrations at the RMA boundary to off-post PRGs.

7.1.2.3 Long-Term Effectiveness and Permanence

The lack of controls or treatment under this alternative increases the potential for exposure since the potential for contaminant migration and additional loading on the boundary systems is increased. All existing controls associated with the Basin A Neck IRA are removed as part of the No Action alternative for the Basin A Plume Group.

7.1.2.4 Reduction of TMV

No treatment is undertaken in the Basin A area as part of this alternative. By eliminating the currently operating Basin A Neck IRA, toxicity of the Basin A Plume Group is not decreased through treatment, and an increase in the mobility and volume of contaminants migrating from the Basin A area. This increase in TMV eventually impacts the boundary systems, which may then require upgraded treatment systems. Some TMV reduction may be experienced as a result of natural attenuation.

7.1.2.5 Short-Term Effectiveness

There is some potential exposure to workers during breaching of the slurry wall, but the risks to workers can be adequately reduced through use of PPE. The activities involved in this alternative do not have any significant impact on the surrounding community or the environment. The protection that is currently provided through the Basin A Neck IRA is eliminated, resulting in a potential increase in contaminant levels in on-post groundwater. RAOs are achieved so long as the boundary systems continue to operate.

7.1.2.6 Implementability

This alternative is both technically and administratively feasible.

7.1.2.7 Costs

The capital cost of this alternative is $32,200, the annual O&M costs are $94,300. The present worth cost is $1,530,000. A summary of the costs is presented in Appendix A, Table A4-1.

7.2 ALTERNATIVE AC-2: CONTINUED EXISTING ACTION

Alternative AC-2 includes continued operation of the existing treatment systems for the Basin A Plume Group. These consist of the Basin A Neck, Shell Trenches, and Lime Settling Basins IRAs. Continued groundwater monitoring and continued compliance with the FFA are also included.

7.2.1 <u>Description of Alternative</u>

7.2.1.1 Extraction/Reinjection

The Basin A Neck IRA is a pump-and-treat system to intercept and treat contamination in groundwater as it moves northwest from Basin A. The extraction system consists of seven alluvial wells that pump a total flow of approximately 10 gpm (James 1993). Water from the Basin F Groundwater IRA is also piped to the Basin A Neck treatment system at a rate of 2.5 gpm and treated with an air stripper. Three gravel-filled recharge trenches are located across the more permeable, deeper portions of the Basin A Neck and are 160 ft, 170 ft, and 180 ft in length. A soil/bentonite slurry wall extends 830 ft across the Basin A Neck between the extraction wells and the recharge trenches to limit recirculation of water between the two systems and inhibit any flow of contaminants not captured by the extraction wells (Figure 7.2-1). Treated water from the CERCLA Wastewater Treatment Plant is conveyed by an underground pipeline, combined with Basin A Neck treatment plant effluent at a rate of 5 gpm, and reinjected in the Basin A Neck reinjection trenches. The CERCLA Wastewater Treatment Plant treats water in a semibatch mode on an as-needed basis, so the water does not flow continually for extended periods of time.

The Shell Trenches IRA is complete. The objective of this IRA is to reduce the lateral and vertical migration of contaminants (dissolved and separate phase) emanating from the Shell Trenches. The IRA consists of a vertical slurry wall barrier and a low-permeability cap.

Construction of the Lime Settling Basins IRA began in 1992, but trenching for the slurry wall was abandoned due to the discovery of unexploded ordnance (UXO). The cap placed over the Lime Settling Basins was completed.

7.2.1.2 Treatment

Groundwater extracted from both the Basin A Neck and the Basin F Groundwater IRAs is treated at the Basin A Neck IRA treatment facility. Approximately 2.5 gpm of groundwater from the Basin F Groundwater IRA is filtered and then treated in an air stripper. The vapor emissions from the air stripper are treated by two vapor-phase carbon vessels in series and an additional backup unit. The Basin F groundwater treated by the air stripper is combined with the Basin A Neck IRA influent and treated by prefiltration through a multimedia filter followed by adsorption in two 2,000-lb carbon vessels in series (one backup vessel is on standby). When the effluent concentration from the first vessel is 50 percent of the influent concentration, the carbon is replaced. The GAC effluent is filtered through multimedia filters and discharged in a 3,000-gallon effluent tank. Water from the tank is then filtered through 5-micron bag filters and pumped to the recharge trenches. Approximately 12 to 13 gpm of groundwater is treated by the Basin A Neck IRA (James 1993).

7.2.1.3 Sidestreams

The Basin A Neck IRA treatment system generates two sidestreams requiring treatment or disposal, spent carbon and filter solids. The GAC in the adsorbers is removed and regenerated at an off-post facility. The filter solids and bag filters are drummed and disposed in a RCRA-approved landfill off post.

7.2.2 Analysis of Alternative

7.2.2.1 Overall Protection of Human Health and the Environment

The Basin A Neck IRA reduces contaminant migration to the boundary systems, thereby reducing future loading on the boundary systems. This reduces the potential for exposure off post.

7.2.2.2 Compliance with ARARs

This alternative is in compliance with all potential action-specific ARARs listed in the Technology Description Volume, Appendix A, including those related to the extraction systems and air emission controls, because it uses an existing system that complies with these ARARs. The existing system also complies with all chemical-specific ARARs listed in Appendix A of the Water DSA and with the FFA so long as PRGs are achieved at the RMA boundary through continued operation of the boundary systems. The boundary systems and the Basin A Neck IRA are located in compliance with all potential location-specific ARARs applicable to groundwater, which are listed in Appendix A, Volume I of the Water DSA.

7.2.2.3 Long-Term Effectiveness and Permanence

Exposure potential is minimized through capture and treatment of contaminants close to the source. The Basin A Neck IRA system reduces the potential for additional loading on the boundary systems. The system may have to operate for more than 100 years, based on the estimated travel times of contaminants from the plumes to the Basin A Neck IRA capture system.

7.2.2.4 Reduction of TMV

Contaminants captured at the Basin A Neck IRA are treated with GAC adsorption. Groundwater is extracted at flow rates of up to 15 gpm, which results in a significant reduction of contaminant TMV. Contaminants are irreversibly transferred to GAC, which requires regeneration off post.

7.2.2.5 Short-Term Effectiveness

This alternative has no impact on workers, surrounding communities, and the environment since no additional actions are undertaken and no existing actions are removed. This alternative

achieves RAOs through continued operation of the boundary systems. The Basin A Neck IRA may be required to operate for more than 100 years.

7.2.2.6 Implementability

The Basin A Neck IRA is already operational and continued operation is technically and administratively feasible.

7.2.2.7 Costs

There is no capital cost associated with this alternative. The O&M costs for continued operation of the Basin A Neck IRA are $1,110,000 per year, and the present worth cost is $17,700,000. A summary of costs for this alternative are presented in greater detail in Appendix A, Table A4-2.

7.3 ALTERNATIVE AC-3/AT-2: MASS REDUCTION, STRIPPING/SORPTION

This alternative consists of groundwater extraction in a mass reduction configuration followed by treatment using air stripping and GAC adsorption. Treatment is accomplished at the Basin A/South Plants combined treatment plant and the treated water is reinjected in recharge trenches. This alternative is accomplished in conjunction with the preferred soils remedial alternatives, which include one cap over the Basin A area, and another cap over the South Plants Central Processing Area. Table 7.3-1 presents the estimated chemical influent concentrations for mass reduction of the Basin A Plume Group under this alternative.

7.3.1 Description of Alternative

7.3.1.1 Extraction/Reinjection

Alternative AC-3 consists of mass reduction systems located in each of the plumes within the Basin A Plume Group (Figure 7.3-1). This alternative is accomplished in conjunction with the preferred soils alternative for capping Basin A and is to be coordinated with the selected South Plants groundwater alternative. The "intercept" well configuration, illustrated in the Water DSA, was modified into a mass reduction configuration in the Water DAA (Alternative AC-3) because

further hydrogeologic evaluation suggests that site conditions favor a mass reduction approach due to the relatively low mobility of many contaminants. The Basin A Neck IRA also continues to operate.

The total estimated flow from the Basin A Plume Group is approximately 10 gpm: 4 gpm from South Plants North Plume, 3 gpm from the Basin A Plume, and 3 gpm from the Section 36 Bedrock High Plumes. The mass reduction phase of operations for the Basin A Plume Group is accomplished in a relatively short amount of time (approximately 10 years), based on volume calculations of the quantity of water and contaminant mass removed (Section 3.2.3). The Basin A Neck IRA intercept system continues to operate and will extract remaining contaminants after completion of the mass reduction phase and capping of Basin A under the soils medium alternative. The cap to be emplaced over the Basin A area is discussed and costed in the Soils DAA.

All extraction wells under this alternative are constructed using 12-inch-diameter borings with gravel pack surrounding the 6-inch-diameter casing and screen (thereby increasing the effective intake radius of the wells), and all pipelines are double walled. All submersible pumps in wells are one-third horsepower and all booster pumps are 1.5 horsepower.

The mass reduction system located in the South Plants North Plume consists of twelve extraction wells, each extracting approximately one-third gpm (4 gpm total). The wells are located in a north-south orientation along the axis of the South Plants North Plume (Figure 7.3-1). The wells are approximately 35 ft deep with 15-ft-long well screens that extend into both the alluvium and the weathered Denver Formation. The total flow of 4 gpm for the South Plants North Plume is pumped to a collection tank and from there is pumped to the treatment plant via a buried pipeline to the proposed Basin A/South Plants combined treatment plant near South Plants. The treated water from the South Plants North Plume is reinjected along with all other treated water from the Basin A/South Plants combined treatment plant in two reinjection trenches located in permeable alluvium in the northwest portion of Section 27.

The mass reduction system located in the Basin A Plume consists of eight 35-ft-deep wells located in a linear north-south orientation along the axis of the Basin A Plume. The extraction wells pump a total of 3 gpm. The extracted groundwater is collected in a collection tank, as described for the South Plants North Plume, and is piped along with the Section 36 Bedrock Ridge Plumes groundwater to the Basin A/South Plants combined treatment plant.

There are three wells located along the plume axis of each Section 36 Bedrock Ridge Plume. The three wells in the North Section 36 Bedrock Ridge Plume extract approximately 1 gpm, and the three wells located in the South Section 36 Bedrock Ridge Plume extract approximately 2 gpm. The total of 3 gpm of water from both plumes is collected in a collection tank and piped to the Basin A Plume transport piping where it is combined with the 3 gpm from the Basin A Plume for treatment at the Basin A/South Plants combined treatment plant.

Treated water is pumped from the Basin A/South Plants combined treatment plant to the reinjection trenches through single-walled PVC pipe. The recharge trenches are lined with a geotextile filter fabric, backfilled with clean gravel, and covered with geotextile filter fabric and 3 ft of soil. Injection distribution pipes connect to well points made of PVC and extend 3 ft into the gravel backfill. The recharge trenches are constructed to ensure that water is recharged back to the aquifer without restriction of vertical flow from possible impermeable layers in the alluvium.

Each of the proposed extraction systems under Alternative AC-3 requires installation of performance monitoring wells. Groundwater-quality and water-level data from the newly installed performance monitoring wells are used to evaluate the effectiveness and operation of the extraction system. The final location of the wells is based upon review of existing well locations and screened intervals.

7.3.1.2 Treatment

The treatment system in Alternative AT-2 uses air stripping followed by GAC adsorption to remove contamination from the groundwater. Figure 7.3-2 presents a process flow diagram showing the major pieces of treatment equipment as well as tanks, pumps, and filters included in this alternative.

Extracted water is held in a collection tank prior to being treated. From there the water is pumped through a multimedia filter to remove suspended solids and potassium pyrophosphate (PKPP) is added as a sequesterant to keep the iron and manganese from precipitating in the air stripper. The water then enters a 22-ft-high air stripper that is operated with an air/water ratio of 50. The stripper is designed to remove more than 90 percent of the volatile organics, such as benzene and chloroform, from the groundwater. A more detailed description of the air stripping technology is presented in the Technology Description Volume, Section 14.3.

The organic contaminants emitted from the air stripper are destroyed in a catalytic oxidation unit, which uses thermal energy (preheating) in the presence of a catalyst to destroy the contaminants. Supplemental fuel is required for the preheater to completely oxidize the organics. The catalyst must be replaced every 3 to 5 years, and is usually returned to the vendor where the catalyst (platinum) is recovered.

Over time, the packing in the air stripper becomes fouled by the deposition of inorganic complexes. When this occurs, the stripper is shut down and the packing and mist eliminator are washed with an acid solution. The acid rinse is returned to a wastewater tank.

The water effluent from the air stripper is pumped to the GAC adsorbers. GAC treatment is accomplished using two fixed-bed GAC adsorbers that are connected in series and operated in the downflow mode. Each vessel holds 2,000 lbs of GAC. The GAC adsorbers are designed to remove in excess of 95 percent of the DBCP, OCPs, and remaining volatiles with an estimated carbon consumption of 12,000 lbs per year. When the lead carbon vessel reaches an

unacceptable pressure drop due to clogging of the carbon, the vessel is removed from service and backwashed with water from the effluent tank to remove particulates and to re-expand the carbon bed. The backwash water is filtered and returned to the collection tank. A more detailed description of the GAC treatment technology is included in the Technology Description Volume, Section 14.2.

When the lead vessel becomes saturated with contaminants, it is taken off line and the carbon is replaced. Spent carbon is transferred to a storage vessel to await collection by the vendor and new carbon is transferred into the empty adsorber. The order of the vessels in the series is reversed so that the partially saturated adsorber becomes the lead vessel.

The GAC effluent is filtered through a bag filter to remove carbon fines and suspended solids. Filtered effluent is held in a collection tank prior to reinjection.

Under this alternative, the Basin A Neck IRA continues to operate.

7.3.1.3 Sidestreams

This treatment system produces two major sidestreams, vapor emissions from the air stripper and spent carbon from the adsorbers. Smaller streams, such as acid wash water from the air stripper and used bags from the filters, are also generated.

The vapor emissions from the air stripper are treated by catalytic oxidation. Because this process actually destroys the contaminants instead of transferring them to another medium, no further treatment of waste products or sorbents is required. The spent carbon from the adsorbers is collected by the vendor supplying the carbon and is thermally regenerated off post.

The acid wash for the air stripper packing is neutralized in the wastewater tank. It is anticipated that the packing must be replaced once a year. If the packing can be decontaminated, it is sent

to a sanitary landfill, otherwise it is sent to the on-post hazardous waste landfill (as described in Section 6.5 of the Technology Description Volume).

Used bags from the filters also require disposal. Because they have been in contact with hazardous materials, they are drummed and transported to the on-post hazardous landfill. Wastewater in the wastewater tank will be sent to the CERCLA Wastewater Treatment Plant and sediments from wastewater tank are drummed and landfilled.

7.3.2 Analysis of Alternative

7.3.2.1 Overall Protection of Human Health and the Environment

Alternative AC-3/AT-2 removes volatile halogenated organic compounds (VHOs), volatile aromatic organic compounds (VAOs) (benzene), DBCP, and OCPs, achieving a reduction in the contaminant mass in the environment. A significant fraction of the contaminant mass is permanently removed from the plume centers during the first 10 years of operation based on volumetric calculations of the quantity of water and contaminant mass removed. The permanent removal of contaminants decreases the toxicity of the groundwater and the mobility of the contaminants. Contaminants not removed by this alternative are effectively removed to acceptable levels by treatment at the Basin A Neck IRA and the boundary systems, reducing the risks of exposure to human health and the environment. The preferred soils remedial alternative for Basin A, the placement of a cap, reduces leaching of contaminants into the groundwater.

The FFA restrictions on future uses of groundwater at RMA further reduce the potential for off-post exposure.

7.3.2.2 Compliance with ARARs

This alternative is in compliance with all potential action-specific ARARs listed in the Technology Description Volume, Appendix A, including those related to the extraction systems and air emission controls, because it uses expansion of an existing extraction well system similar to existing systems and treatment technologies that comply with these ARARs. The treatment

system complies with all potential chemical-specific ARARs listed in Appendix A, Volume I, of the Water DSA. PRGs are achieved at the RMA boundary through continued operation of the existing boundary systems. The Basin A/South Plants combined treatment plant is to be located in compliance with all potential location-specific ARARs applicable to groundwater, which are also listed in Appendix A, Volume I of the Water DSA.

7.3.2.3 Long-Term Effectiveness and Permanence

This alternative reduces the magnitude of residual risks by permanently removing contamination from the groundwater. The potential for off-post exposure is minimized by the mass removal of contaminants from the Basin A, South Plants North, and Section 36 Bedrock Ridge Plumes in conjunction with the continuing operation of the boundary systems and Basin A Neck IRA.

Contaminants are removed and treated close to the source. The proposed mass removal system lowers the groundwater levels in the Basin A Plume Group, further reducing the potential for migration. The amount of contaminated soil in contact with groundwater is reduced by lowering the water table. A cap placed over the Basin A area as part of the soils medium preferred alternative prevents infiltration, thereby reducing both groundwater migration in the Basin A Plume Group and the leaching of the contaminants from the unsaturated soil column. The Basin A Neck IRA continues to intercept contaminants that migrate from the Basin A Plume Group. This IRA may be required to operate for more than 100 years based on the estimated travel times of contaminants from the plumes to the extraction wells. The boundary systems ensure that any groundwater that is not captured and treated on post meets PRGs at the RMA boundary.

Monitoring occurs during the operation of the treatment system and continues once the system is shut down to evaluate long-term effectiveness and plume migration.

7.3.2.4 Reduction of TMV

This alternative reduces toxicity and mobility of contaminants in the groundwater by mass removal of contaminants at the plume centers followed by treatment and reinjection. Under this

alternative, air stripping removes the majority of the volatile organics and GAC adsorption treats the remaining organic contaminants to the TECs. At the Basin A Neck IRA, organic contaminants are treated with GAC adsorption. These processes are irreversible, and the contaminants removed in the air stripper are destroyed by catalytic oxidation. Contaminants treated with GAC adsorption are transferred to the carbon, which is thermally regenerated. Any contaminants that are not intercepted by the extraction system, or residual contaminants that remain sorbed to the soil in the aquifer and desorb at a later time, are treated by the boundary systems. Toxicity is reduced by the removal of contaminants from the groundwater prior to reinjection.

A mass reduction system extracts the groundwater at the source, reducing the potential for migration through the aquifer. In addition, the water table is lowered and the contaminants are suspended in the soil above the water table (the vadose zone), limiting their mobility. Mobility is further reduced by the placement of a cap over Basin A, which reduces the leaching of contaminants from the vadose zone. In this system, 10 gpm is extracted from the South Plants North, Basin A, and the Section 36 Bedrock Ridge Plumes. The Basin A Neck IRA intercepts the contaminants in the Basin A Neck area. Groundwater, extracted at flow rates up to 15 gpm, is captured and treated in this system. The operation of these systems results in the decrease of contaminant mobility in the Basin A Plume Group and a reduction of contaminant loading on the boundary systems and Basin A Neck IRA.

7.3.2.5 Short-Term Effectiveness

In general, the construction, operation, and final demobilization of this alternative have minimal negative impact on the environment, workers, and the surrounding community. On-post workers are potentially exposed to contaminants by dermal contact and dust inhalation during excavation and well and trench installation. To reduce the potential for such exposure, geophysical surveys to clear UXO, dust control measures, and PPE are used.

Operators of the system must also concern themselves with proper chemical-handling techniques when washing the stripper packing with sulfuric acid. To reduce the potential for exposure, personnel are made aware of on-post health and safety procedures and PPE is used.

RAOs are achieved under this alternative. In the first 10 years, a significant fraction of contaminant mass is removed from the plume centers. The contaminants are extracted and treated, reducing the volume and toxicity of contaminants in the groundwater. The mass reduction treatment system operates for 10 years. The Basin A Neck IRA may be required to operate for more than 100 years.

7.3.2.6 Implementability

This alternative is technically feasible. Extraction/reinjection, air stripping, and GAC adsorption are proven and commercially available technologies. As discussed in the Technology Description Volume (Sections 5, 14.3, and 14.2), these technologies are currently being used at RMA. The extraction system incorporates existing wells where possible. The operators do not require any further training for operation of this alternative. The Basin A Neck IRA is currently operating and no further changes to this system are required.

The alternative is expected to be reliable. The treatment system requires minimal down time for equipment maintenance; in many cases, maintenance can be performed without shutting down the entire system. The system has automated controls that ensure continuous operation with little supervision.

GAC and air stripper packing are readily available and supplied in sufficient quantities by large, technically proficient vendors. Spent carbon is transported and regenerated by vendors. Sediments that settle during treatment and bag filters are disposed in the on-post RCRA landfill. Precious metals are recovered from the spent catalyst in the catalytic oxidation unit by the supply vendor.

Administratively, this alternative is easily implementable. It requires an operation and maintenance program for the treatment system, contracts with GAC suppliers, vendors who manage hazardous wastes, periodic site monitoring, and 5-year reviews. An air permit for the treatment system is not required, although the emissions from the air stripper must comply with ARARs.

7.3.2.7 Costs

The capital cost of this treatment system is estimated at \$5,830,000. Approximate annual O&M costs for the first 10 years (while the treatment system operates) are \$1,840,000. The annual O&M costs for the remaining 20 years, including monitoring and Basin A Neck IRA operation, are \$1,220,000. The present worth cost for 30 years of operation is estimated at \$30,300,000. A summary of costs for this alternative is presented in Appendix A, Table A4-3.

7.4 ALTERNATIVE AC-3/AT-4: MASS REDUCTION, STRIPPING/OXIDATION/SORPTION

This alternative consists of groundwater extraction in a mass reduction configuration followed by treatment using air stripping, oxidation, and sorption. Treatment is accomplished at a Basin A/South Plants combined treatment plant and the treated water is reinjected in recharge trenches in the northwest portion of Section 27 west of South Plants. This alternative is accomplished in conjunction with the preferred soils remedial activities, which include one cap over the Basin A area, and another cap over the South Plants Central Processing Area. Table 7.3-1 presents the estimated chemical influent concentrations for mass reduction of the Basin A Plume Group under this alternative. Under this alternative the Basin A Neck IRA continues to operate as described in Section 7.3.1.1.

7.4.1 Description of Alternative

7.4.1.1 Extraction/Reinjection

This alternative includes the same groundwater control system that is used for Alternative AC-3/AT-2 (Section 7.3.1.1).

7.4.1.2 Treatment

The treatment system for Alternative AT-4 uses air stripping followed by oxidation and GAC adsorption to remove contamination from the groundwater. Figure 7.4-1 presents a process flow diagram showing the major pieces of treatment equipment as well as the tanks, pumps, and filters included in this alternative. The pre-treatment and air stripping portions of this alternative are the same as those described for alternative AC-3/AT-2 (Section 7.3.1.2).

The air stripper is designed to remove more than 90 percent of the volatile organics, including chloroform and benzene, from the groundwater. A more detailed description of the air stripping technology is presented in the Technology Description Volume, Section 14.3. Volatile organics emitted from the air stripper are destroyed using catalytic oxidation as described in Section 7.3.1.2.

Hydrogen peroxide is added to the effluent from the air stripper and the water is pumped to the oxidation reactor. Ozone, produced from air with an ozone generator, is injected into the reactor. The oxidation reactor has a retention time of 30 minutes and is designed to destroy more than 90 percent of the OCPs, DBCP, and the remaining volatile organics in the groundwater. Off gas from the oxidation reactor is destroyed by the catalytic oxidation unit used for the air stripper. A more detailed description of this technology is presented in the Technology Description Volume, Section 14.1.

After treatment in the oxidation reactor, the water is pumped through a multimedia filter and then to a GAC adsorption system to remove the remaining organics (mostly OCPs). GAC treatment is accomplished using two fixed-bed GAC adsorbers in series, operated in downflow mode. Each vessel holds 2,000 lbs of GAC; the estimated carbon consumption is 150 lbs per year. Operation and maintenance of the adsorption system for this alternative are the same as for Alternative AC-3/AT-2 and are described in Section 7.3.1.2. A more detailed description of the GAC treatment technology is included in the Technology Description Volume, Section 14.2.

Bag filters remove any GAC present in the effluent stream. The filtered water is held in a collection tank prior to reinjection.

7.4.1.3 Sidestreams

This treatment system produces three major sidestreams: vapor emissions from the air stripper, vapor emissions from the oxidation reactor, and spent carbon. In addition, smaller streams are generated including the acid wash water from the air stripper, backwash water, and used bags from the filters.

Vapor emissions from both the air stripper and the oxidation reactor are treated with catalytic oxidation. Because this process actually destroys the contaminants instead of transferring them to another medium, no further treatment of the vapor phase is required. Contaminants treated with GAC adsorption are transferred to the GAC, which is thermally regenerated by the vendor off post.

The acid wash for the air stripper is disposed as for Alternative AC-3/AT-2 (Section 7.3.1.3). Used bags from filters are also disposed as described in Section 7.3.1.3.

7.4.2 Analysis of Alternative

7.4.2.1 Overall Protection of Human Health and the Environment

Alternative AC-3/AT-4 permanently removes a significant fraction of the contaminant mass of VHOs, VAOs (benzene), DBCP, and OCPs from the plume centers during the 10 years of operation, thereby reducing the toxicity of the groundwater and the mobility of the contaminants. Contaminants that are not removed by this alternative are effectively removed to acceptable levels by treatment at the Basin A Neck IRA and the boundary systems, reducing the risks of exposure to human health and the environment. The preferred soils remedial alternative for Basin A, the placement of a cap, reduces leaching of contaminants into the groundwater. The FFA restrictions on the future uses of groundwater at RMA further reduce the potential for on-post exposure.

7.4.2.2 Compliance with ARARs

This alternative is in compliance with all potential action-specific ARARs listed in the Technology Description Volume, Appendix A, including those related to the extraction systems and air emission controls, because it uses an extraction well system similar to existing systems and treatment technologies that comply with these ARARs. The treatment system also complies with all potential chemical-specific ARARs listed in Appendix A, Volume I, of the Water DSA. PRGs are achieved at the RMA boundary through continued operation of the existing boundary systems. The Basin A/South Plants combined treatment plant is to be located in compliance with all potential location-specific ARARs applicable to groundwater, which are also listed in Appendix A, Volume I, of the Water DSA.

7.4.2.3 Long-Term Effectiveness and Permanence

This alternative reduces the magnitude of residual risks by permanently removing contamination from the groundwater. The potential for off-post exposure is minimized by the additional mass removal of contaminants from plume centers and by the Basin A Neck IRA system and the boundary systems.

Contaminants are removed and treated at the source. The proposed mass reduction system lowers the groundwater levels in the Basin A Plume Group, further reducing the potential for migration. The amount of contaminated soil in contact with groundwater is reduced by lowering the water table. A cap placed over the Basin A area as part of the preferred alternative for the soils medium prevents infiltration, thereby reducing groundwater migration in the Basin A Plume Group. The cap also reduces leaching of contaminants suspended in the soil column above the water table. The Basin A Neck IRA continues to intercept any contaminants that migrate from the Basin A Plume Group, but it may be required to operate for more than 100 years (based on estimated contaminant travel times). The boundary systems ensure that any groundwater that is not captured on post meets PRGs at the RMA boundary.

Monitoring occurs during the operation of the treatment system and continues once the system is shut down to evaluate long-term effectiveness and plume migration.

7.4.2.4 Reduction of TMV

This alternative reduces toxicity and mobility of contaminants in the groundwater by mass removal of the contaminants at the plume center followed by treatment and reinjection. The groundwater extracted from the South Plants North, Basin A, and Section 36 Bedrock Ridge Plumes is treated by a combination of oxidation, air stripping, and GAC adsorption. The oxidation process destroys a large fraction of the contaminants and volatilizes a fraction of the volatile organics. Air stripping removes the majority of volatile organics, and GAC adsorption treats the remaining organic contaminants to the TECs. At the Basin A Neck IRA, organic contaminants are treated with GAC adsorption. All of these treatment processes irreversibly remove contaminants from the groundwater: contaminants are destroyed in the oxidation reactor, and those contaminants volatilized in the air stripper or in the oxidation reactor, or are destroyed by catalytic oxidation. Contaminants treated with GAC adsorption are transferred to GAC, which is thermally regenerated off post. Any contaminants that are not intercepted by the extraction system, any residual contaminants after treatment, or any contaminants that remain sorbed to the soil in the aquifer and desorb at a later time are treated at the Basin A Neck IRA or the boundary systems. Toxicity is reduced by the removal of the contaminants from the groundwater prior to reinjection.

A mass reduction system extracts the groundwater at the source, reducing the potential for migration through the aquifer. The water table is lowered and the contaminants are suspended in the soil vadose zone. Mobility is therefore reduced by lowering the water table. Mobility is further reduced by the placement of a cap over Basin A, which reduces the leaching of contaminants from the vadose zone. In this system, a total of 10 gpm is extracted from the South Plants North, Basin A, and Section 36 Bedrock Ridge Plumes. The Basin A Neck IRA captures and treats contaminated groundwater at flow rates of up to 15 gpm. These systems result in a

decrease of contaminant mobility in the Basin A Plume Group and reduction of contaminant loading on the boundary systems.

7.4.2.5 Short-Term Effectiveness

In general, construction, operation, and final demobilization of this alternative have minimal negative impact on the environment, workers, and the surrounding community. On-post workers are potentially exposed to contaminants through dermal contact and dust inhalation during excavation and well and trench installation. To reduce the potential for such exposure, dust control measures and PPE are used.

Operators of the system must also concern themselves with proper chemical-handling techniques when washing the stripper packing with sulfuric acid; when monitoring the oxidation reactor, which requires ozone, a toxic gas; and when handling spent carbon. To reduce the potential for exposure, personnel are made aware of on-post health and safety procedures and PPE is used.

RAOs are achieved for this alternative. In the first 10 years, a significant fraction of the contaminant mass is removed from the plume centers and treated, reducing volume and toxicity of contaminants in the groundwater. The mass reduction treatment system operates for approximately 10 years based on the estimated volume of the most highly contaminated groundwater to be removed from the plume. The Basin A Neck IRA may be required to operate for more than 100 years based on the estimated travel times of contaminants from the plumes to the Basin A Neck IRA. However, the extraction rate for the IRA can be expected to decrease with time.

7.4.2.6 Implementability

This alternative is technically feasible. Extraction/reinjection, air stripping, and GAC adsorption are proven and readily available technologies. As discussed in the Technology Description Volume (Sections 5, 14.3, and 14.2), these technologies are currently being used at RMA. The advanced oxidation process, which uses hydrogen peroxide and ozone, is considered an

innovative technology. Pilot-scale studies may be required as follow up to the U.S. Army Corps of Engineers' Wastewater Experiment Station (WES) bench-scale treatability studies to ensure its implementability (Zappi 1993).

The equipment required is all commercially available from several vendors, with the exception of that required for oxidation. A limited number of vendors supply oxidation equipment. The extraction system incorporates existing wells where possible. The Basin A Neck IRA is currently operating and no further changes to the system are required.

The alternative is expected to be reliable. The treatment system requires minimal down time for equipment maintenance; in many cases, maintenance can be performed without shutting down the entire system. The system has automated controls that ensure continuous operation with little supervision.

GAC and air stripper packing are produced and supplied in sufficient quantities by large, technically proficient vendors. GAC is transported and regenerated by vendors as part of the supply contract. Sediments that settle out during treatment and bag filters are disposed in the on-post RCRA landfill. Precious metals are recovered from the spent catalyst in the catalytic oxidation unit by the supply vendor.

Administratively, this alternative is easily implementable. It requires an operation and maintenance program for the treatment system, contracts with GAC suppliers, vendors who manage hazardous wastes, periodic site monitoring, and 5-year reviews. An air permit for the treatment system is not required, although the emissions from the air stripper must comply with ARARs.

7.4.2.7 Costs

The capital cost of this treatment system is estimated at $6,380,000. Approximate annual O&M costs for the first 10 years (while the treatment system operates) are $1,770,000. The annual O&M costs for the remaining 20 years, including monitoring and Basin A Neck IRA operation, are $1,200,000. The present worth cost for 30 years of operation is estimated at $30,200,000. A summary of costs for this alternative is presented in Appendix A, Table A4-4.

7.5 ALTERNATIVE AC-7: CLAY/SOIL CAP

This alternative is accomplished in conjunction with the placement of a cap over Basin A, an alternative developed for the soils medium. In this alternative, a cap is constructed over Basin A and the Basin A Neck IRA continues to operate. The difference between Alternative AC-3, described in Section 7.3, and Alternative AC-7 is that in the former, mass reduction is accomplished before the cap is installed, and that in the latter, no mass reduction occurs before the cap is installed.

7.5.1 Description of Alternative

7.5.1.1 Extraction/Reinjection

The clay/soil cap to be placed over Basin A consists of a 2-ft-thick layer of compacted low-permeability soils overlain first by a 1-ft layer of gravel and cobbles to prevent burrowing animals from penetrating the low-permeability soil layer, then by a 4-ft soil vegetative layer that includes 6 inches of top soil. The vegetative cover consists of a mixture of native grasses selected for resistance to drought and for a shallow root system (typically less than 18 inches). The vegetative cover requires maintenance to prevent trees and shrubs from growing in the cap. Depending on the source used for the vegetative soil layer, the cap may require fertilization to promote a healthy ecosystem. Filling and regrading of Basin A may be required to control and channel surface water flow. Areas within Basin A that have already received containment treatment, such as the Lime Settling Basins and the Shell Trenches, are not changed, but may be surrounded or covered by the newly capped areas.

Plume evaluation wells, used as monitoring wells, will provide groundwater-quality and water-level data. The monitoring program, conducted for at least 30 years, is used to evaluate the effectiveness and operation of the extraction system.

Alternative AC-7 will only be considered if completed in conjunction with the placement of a cap over Basin A as a soils remedial alternative. The cap reduces groundwater recharge and contaminant leaching in Basin A. The Basin A Neck IRA captures most of the potential contamination migrating from the Basin A area. If the soil cap is not installed, Alternative AC-7 would not be as effective in reducing TMV as is Alternative AC-2.

7.5.1.2 Treatment

No treatment is required for this alternative beyond continued operation of the Basin A Neck IRA treatment system. This system is described in greater detail in Section 7.2.1.2.

7.5.1.3 Sidestreams

No additional sidestreams are generated by this alternative beyond those currently generated by the Basin A Neck IRA treatment system. These are discussed in Section 7.2.1.3.

7.5.2 Analysis of Alternative

7.5.2.1 Overall Protection of Human Health and the Environment

Alternative AC-7 makes use of the preferred soils remedial alternative for Basin A, a cap, as well as the Basin A Neck IRA to reduce the exposure to human health and the environment. The cap reduces groundwater flow and the leaching of contaminants through Basin A, minimizing contaminant transport, and the Basin A Neck IRA reduces the contaminant loading at the NBCS, contributing to the protection of human health and the off-post environment. The Basin A cap is discussed in more detail in the Soils DAA.

7.5.2.2 Compliance with ARARs

This alternative is in compliance with all potential action-specific ARARs listed in the Technology Description Volume, Appendix A, including those related to the extraction systems and air emission controls, because it uses an existing system that complies with these ARARs. The existing system also complies with all chemical-specific ARARs listed in Appendix A, Volume I, of the Water DSA and the FFA so long as PRGs are achieved at RMA boundary through continued operation of the Basin A Neck IRA and boundary systems. The location of the Basin A Neck IRA and the boundary systems are in compliance with all potential location-specific ARARs applicable to groundwater, which are listed in Appendix A, Volume I, of the Water DSA.

7.5.2.3 Long-Term Effectiveness and Permanence

This alternative reduces the magnitude of residual risk by immobilizing the contaminants in the soil and treating the contaminants in the groundwater. The Basin A Neck IRA is the primary interceptor of contaminants migrating from the Basin A Plume. The NWBCS and NBCS act as secondary interceptors of groundwater to ensure PRGs are met at the RMA boundary. The Basin A cap reduces leaching of contaminants through the vadose zone and also reduces groundwater recharge. The Basin A cap and the Basin A Neck IRA reduces the potential for off-post exposure by limiting contaminant migration and loading on the boundary systems.

7.5.2.4 Reduction of TMV

This alternative uses containment combined with treatment to reduce contaminant TMV in groundwater. The Basin A cap reduces the mobility and volume of contaminated groundwater by restricting groundwater recharge, while the Basin A Neck IRA reduces the toxicity of groundwater by GAC adsorption. In this treatment process, contaminants are irreversibly transferred to the GAC, which is thermally regenerated off post. The Basin A Neck IRA reduces the volume of contaminants in the groundwater prior to reinjection, thus minimizing migration of contaminants and reducing loading on the boundary systems. A groundwater flow of 10 to 12 gpm (which decreases when the cap minimizes infiltration) is treated by the Basin A Neck

IRA. Further reduction of these contaminants occurs at the boundary, if necessary, to meet PRGs.

The mobility of contaminants sorbed to the soil is reduced by lowering the groundwater table through pumping by the Basin A Neck extraction wells and the installation of the cap. Any contaminants that may desorb from the soil and are not captured by the Basin A Neck IRA are treated by the boundary systems.

7.5.2.5 Short-Term Effectiveness

Steps are taken to ensure minimal impacts to the environment, on-post workers, and the community. On-post workers are required to wear appropriate PPE to reduce the potential for exposure. Operators of the Basin A Neck IRA and carbon vendors need to take the appropriate measures to prevent exposure to contaminants when handling and regenerating GAC. Dust control techniques are used to minimize dust dispersion during cap installation for environmental and community protection, and air monitoring is performed during cap construction to evaluate contaminant transport through the air and assess the potential risk to the community. RAOs are achieved if the boundary systems continue to operate. The Basin A cap is permanent, and the Basin A Neck IRA may be required to operate for 100 years, based on the estimated travel times of contaminants.

7.5.2.6 Implementability

Caps have been constructed at numerous hazardous waste sites and have been proven to be effective and reliable. Capping technology is widely accepted and the equipment required for construction is commercially available through numerous vendors. The Basin A Neck IRA is currently operating satisfactorily at RMA; however, upgrades to the system can easily be performed if needed.

7.5.2.7 Costs

There is no capital cost for this alternative because the cap is costed under Alternative 6F for the Basin A soils medium group. The O&M costs for 30 years, including the operation of the Basin A Neck IRA and monitoring, are approximately $1,110,000 annually. The present worth cost for 30 years of operation is estimated at $17,400,000. A summary of costs for this alternative is presented in Appendix A, Table A4-5.

Table 7.0-1 Comparative Analysis of Alternatives: Basin A Plume Group

Criteria	ALT AC-1 No Action	ALT AC-2 Continued Existing Action
1. Overall protection of human health and the environment	Contaminants free to migrate to boundary; will be treated by the boundary systems	Reduces potential exposure and removes contaminant mass from the environment
2. Compliance with ARARs –Action-specific –Location-specific –Chemical-specific	Complies with action-, location-, and chemical-specific ARARs if boundary systems continue to operate	Complies with action-, location-, and chemical-specific ARARs if boundary systems continue to operate
–Criteria, advisories, and guidance	Complies with FFA.	Complies with FFA
3. Long-term effectiveness and permanence –Magnitude and residual risks –Adequacy and reliability of controls	Increases potential for exposure, due to contaminant migration through Basin A Neck and increases potential for additional loading on boundary systems Monitoring continues Existing controls at Basin A Neck IRA removed	Minimizes potential for off-post exposure; contaminants removed and treated at Basin A Neck IRA; reduced potential for additional loading at boundary systems Monitoring continues Adequate existing controls, but long-term maintenance required
4. Reduction of TMV through treatment –Treatment process used and materials treated –Degree and quantity of TMV reduction –Irreversibility of TMV reduction	No treatment or action undertaken TMV reduced over time by natural attenuation	Contaminants removed by GAC adsorption at Basin A Neck IRA 10-15 gpm removed and treated at Basin A Neck IRA Contaminants irreversibly transferred to GAC, which requires regeneration off post
5. Short-term effectiveness –Protection of workers during remedial action –Protection of community during remedial action –Environmental impacts of remedial action –Time until RAOs are achieved	Minimal negative impact on workers and surrounding community Contaminates free to migrate RAOs achieved if boundary systems in operation	Minimal negative impact on workers and surrounding community No additional impact on environment System may require operation for more than 100 years RAOs achieved if boundary systems in operation
6. Implementability –Technical feasibility –Administrative feasibility –Availability of services and materials	Technically and administratively feasible Increases loading on existing boundary systems	Technically and administratively feasible Already operational
7. Costs		
–Capital Cost	$32,200	$0
–Annual O&M Cost	$94,300	$1,110,000
–Present Worth	$1,530,000	$17,700,000

Table 7.0-1 Comparative Analysis of Alternatives: Basin A Plume Group

Criteria	ALT AC-3/AT-2 Mass Reduction, Stripping/Sorption	ALT AC-3/AT-4 Mass Reduction, Stripping/Oxidation/Sorption
1. Overall protection of human health and the environment	Removes contaminant mass from the environment	Removes contaminant mass from the environment
2. Compliance with ARARs –Action-specific –Location-specific –Chemical-specific –Criteria, advisories, and guidance	Complies with action-, location-, and chemical-specific ARARs	Complies with action-, location-, and chemical-specific ARARs
3. Long-term effectiveness and permanence –Magnitude and residual risks –Adequacy and reliability of controls	Minimizes potential for off-post exposure; contaminants removed and treated at source and intercepted and treated at boundary systems and Basin A Neck IRA; lowers groundwater levels in Basin A Monitoring program continues	Minimizes potential for off-post exposure; contaminants removed and treated at source and intercepted and treated at boundary systems and Basin A Neck IRA; lowers groundwater levels in Basin A Monitoring program continues
4. Reduction of TMV through treatment –Treatment process used and materials treated –Degree and quantity of TMV reduction –Irreversibility of TMV reduction	Contaminants removed by GAC adsorption at Basin A Neck IRA; the Basin A Plume, Section 36 Bedrock Ridge Plumes, and South Plants North Plume treated by air stripping and GAC adsorption; mass reduction system at source reduces potential migration through the aquifer 10 gpm from South Plants North, Basin A, and Section 36 Bedrock Ridge Plumes and up to 15 gpm at Basin A Neck IRA removed and treated Contaminants transferred to GAC, which requires regeneration, or transferred to vapor-phase and destroyed by catalytic oxidation	Contaminants removed by GAC adsorption at Basin A Neck IRA; the Basin A Plume, Section 36 Bedrock Ridge Plumes, and South Plants North Plume treated by air stripping, oxidation, and GAC adsorption; mass reduction system at source reduces potential migration through the aquifer; 10 gpm from South Plants North, Basin A, and Section 36 Bedrock Ridge Plumes and up to 15 gpm at Basin A Neck IRA removed and treated; Contaminants transferred to liquid-phase GAC, which requires regeneration, are destroyed by oxidation, or are transferred to the vapor phase in air stripper. Air stripper and oxidation emissions destroyed by catalytic oxidation; lower GAC consumption than AT-2
5. Short-term effectiveness –Protection of workers during remedial action –Protection of community during remedial action –Environmental impacts of remedial action –Time until RAOs are achieved	Minimal negative impact on the environment, surrounding community and workers RAOs achieved; mass reduction treatment system operates for 10 years; Basin A Neck IRA may require operation for more than 100 years	Minimal negative impact on the environment, surrounding community, and workers RAOs achieved; mass reduction treatment system operates for 10 years; Basin A Neck IRA may require operation for more than 100 years
6. Implementability –Technical feasibility –Administrative feasibility –Availability of services and materials	Technically feasible: demonstrated, available technologies, reliable equipment, and experienced operators Administratively feasible	Technically feasible: air stripping and GAC adsorption are demonstrated, available technologies; advanced oxidation process is innovative and requires more oversight and additional training for operators Administratively feasible

Criteria	ALT AC-3/AT-2 Mass Reduction, Stripping/Sorption	ALT AC-3/AT-4 Mass Reduction, Stripping/Oxidation/Sorption
7. Costs		
–Capital Cost	$5,830,000	$6,380,000
–Annual O&M Cost	$1,840,000	$1,770,000
–Present Worth	$30,300,000	$30,200,000

Table 7.0-1 Comparative Analysis of Alternatives: Basin A Plume Group

Criteria	ALT AC-7 Clay/Soil Cap
1. Overall protection of human health and the environment	Reduces potential for contaminant migration; removes contaminant mass from the environment
2. Complies with ARARs –Action-specific –Location-specific –Chemical-specific –Criteria, advisories, and guidance	Complies with action-, location-, and chemical-specific ARARs
3. Long-term effectiveness and permanence –Magnitude and residual risks –Adequacy and reliability of controls	Minimizes potential for off-post exposure; contaminants removed and treated at boundary systems and Basin A Neck IRA; lowers groundwater levels in Basin A Monitoring program continues
4. Reduction of TMV through treatment –Treatment process used and materials treated –Degree and quantity of TMV reduction –Irreversibility of TMV reduction	Cap reduces migration of contaminants; contaminants are removed by GAC adsorption at Basin A Neck IRA 12 gpm at Basin A Neck IRA removed and treated Contaminants transferred to GAC which requires regeneration
5. Short-term effectiveness –Protection of workers during remedial action –Protection of community during remedial action –Environmental impacts of remedial action –Time until RAOs are achieved	Minimal negative impact on the environment, surrounding community, and workers RAOs achieved; may require operation of Basin A Neck IRA for greater than 100 years
6. Implementability –Technical feasibility –Administrative feasibility –Availability of services and materials	Technically feasible: demonstrated, available technologies, reliable equipment, and experienced operators Administratively feasible
7. Costs*	
–Capital Cost	0
–Annual O&M Cost	$1,100,000
–Present Worth	$17,400,000

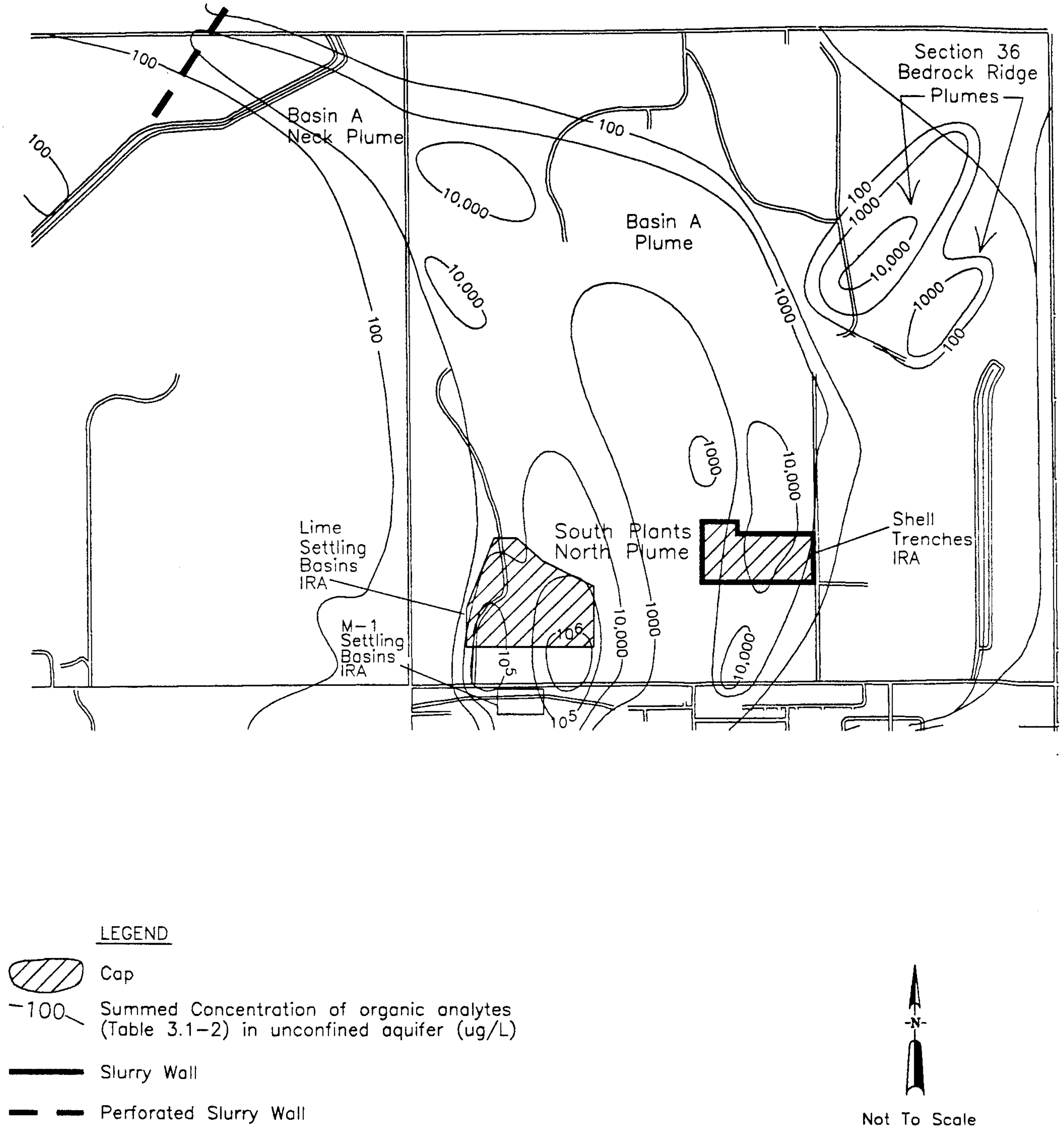
ARAR	Applicable or Relevant and Appropriate Requirements
FFA	Federal Facility Agreement
GAC	Granular Activated Carbon
IRA	Interim Response Action
O&M	Operation and Maintenance
RAO	Remedial Action Objectives
TMV	Toxicity, Mobility, or Volume
*	Costs for the cap are included in soils Alternative 6F for the Basin A soils medium group.

Table 7.3-1 AC-3 Basin A Plume Group Estimated Influent Concentrations

Chemical Group / Compound	Estimated Influent Concentration (ug/l)	Target Effluent Concentration (ug/l)
Volatile Halogenated Organic Compounds (VHOs)		
1,2-Dichloroethane	7.8	10
1,1-Dichloroethylene	4.4	14
1,1,1-Trichloroethane	1.0	400
1,1,2-Trichloroethane	1.3	6
Carbon tetrachloride	1.2	10
Chlorobenzene	190.	50
Chloroform	6800.	30
Methylene chloride	98.	10
Tetrachloroethylene	100.	10
Trichloroethylene	23.	10
Volatile Hydrocarbon Compounds (VHCs)		
Dicyclopentadiene	19.	92
Volatile Aromatic Organic Compounds (VAOs)		
Benzene	620.	10
Ethylbenzene	1.6	1360
o-and p-Xylene	5.6	20000
Toluene	27.	2000
Organosulfur Compounds, Mustard Agent Related (OSCMs)		
1,4-Oxathiane	17.	320
Dithiane	45.	36
Organosulfur Compounds, Herbicide Related (OSCHs)		
Chlorophenylmethyl sulfide	33.	60
Chlorophenylmethyl sulfone	92.	72
Chlorophenylmethyl sulfoxide	12.	72
Organophosphorous Compounds, GB-Agent Related (OPHGBs)		
Diisopropylmethyl phosphonate	260.	1200
Isopropylmethyl phosphonic acid	120.	1400
Organophosphorus Compounds, Pesticide Related (OPHPs)		
Atrazine	6.5	8.06
Dibromochloropropane (DBCP)		
Dibromochloropropane	2.8	0.40

Table 7.3-1 AC-3 Basin A Plume Group Estimated Influent Concentrations

Chemical Group / Compound	Estimated Influent Concentration (ug/l)	Target Effluent Concentration (ug/l)
Semivolatile Halogenated Organic Compounds (SHOs)		
Hexachlorocylopentadiene	0.27	0.46
Organochlorine Pesticides (OCPs)		
Aldrin	0.71	0.10
Chlordane	0.97	4
PPDDE	0.06	0.11
PPDDT	0.14	0.20
Dieldrin	0.41	0.10
Endrin	0.20	0.40
Isodrin	0.22	0.12
Arsenic		
Arsenic	45.	100
Mercury		
Mercury	0.48	4
ICP Metals		
Cadmium	4.3	10
Chromium	13.	200
Lead	8.5	100

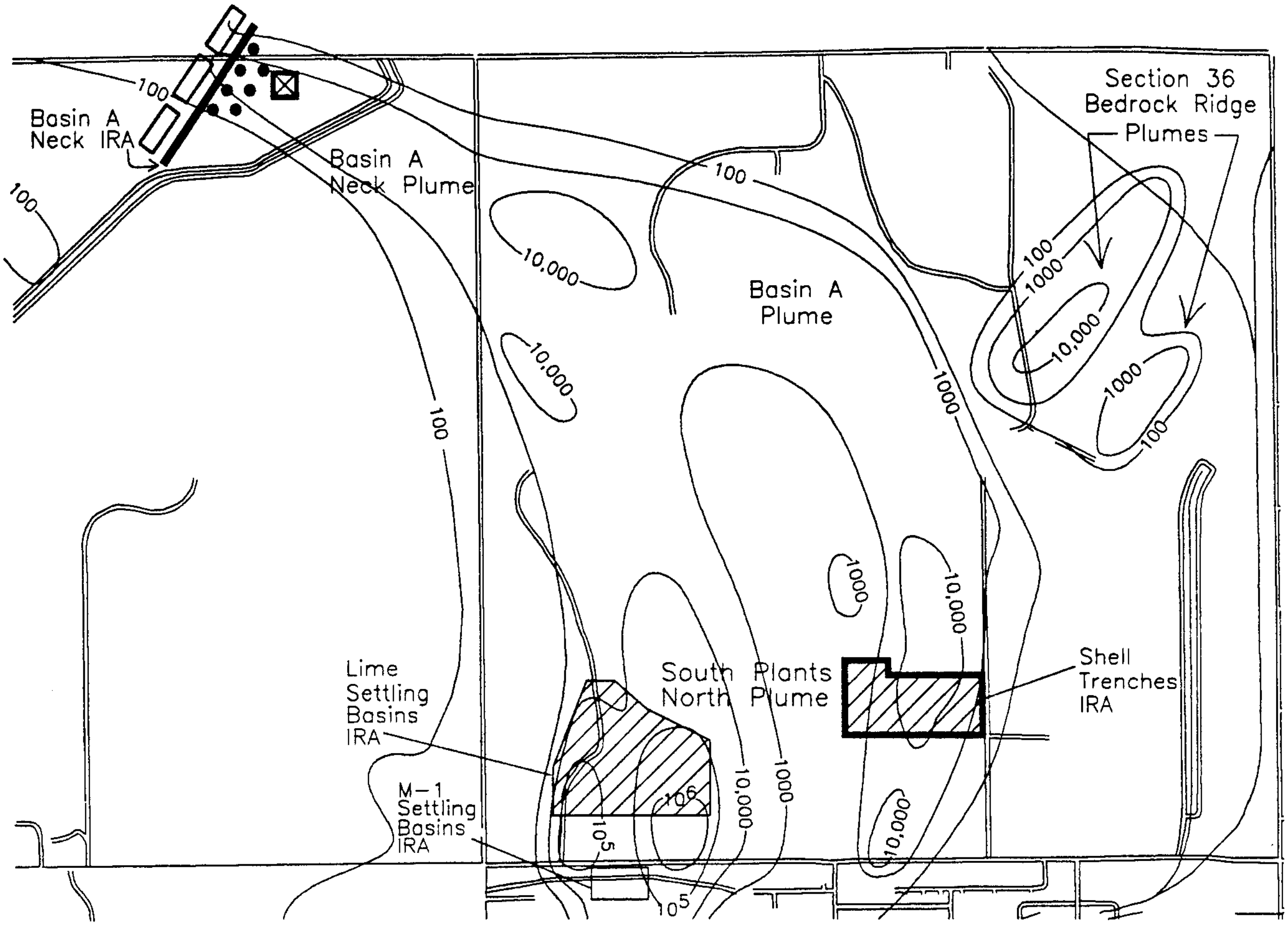


SOURCE: Water DSA Plume Map

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 7.1-1
Schematic for Basin A Plume Group
Control Alternative AC-1

Prepared by:
EBASCO SERVICES INCORPORATED



LEGEND

▨ Cap

—100— Summed Concentration of organic analytes (Table 3.1-2) in unconfined aquifer (ug/L)

● Extraction Well

▭ Recharge Trench

— Slurry Wall

☒ Treatment Plant

-N-

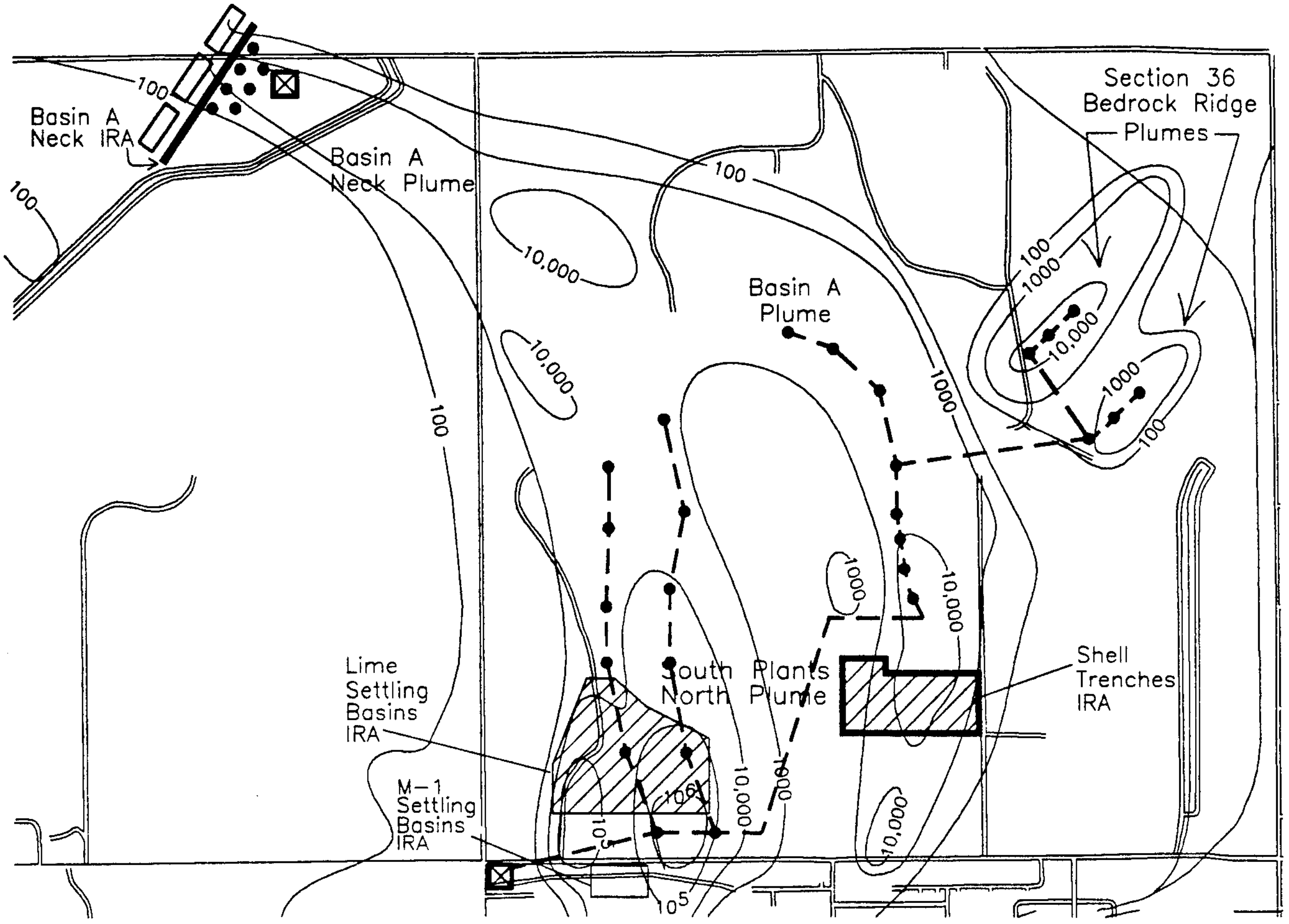
Not To Scale

SOURCE: Water DSA Plume Map

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 7.2-1
Schematic for Basin A Plume Group
Control Alternative AC-2

Prepared by:
EBASCO SERVICES INCORPORATED



LEGEND

▨ Cap

~100~ Summed Concentration of organic analytes (Table 3.1-2) in unconfined aquifer (ug/L)

● Extraction Well

▭ Recharge Trench

━ Slurry Wall

– – – Transport Pipe

☒ Treatment Plant

N

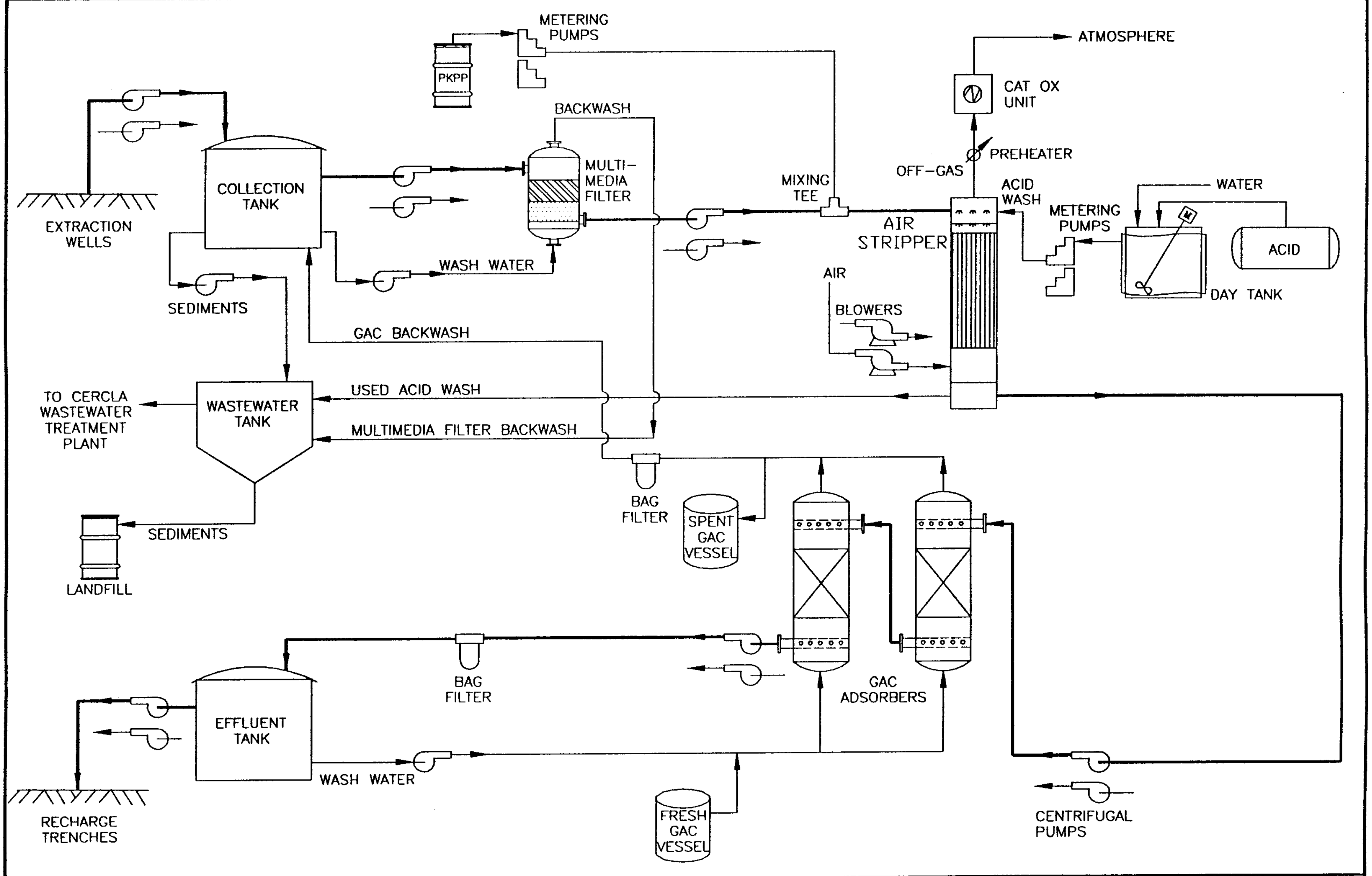
Not To Scale

SOURCE: Water DSA Plume Map

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 7.3-1
Schematic for Basin A Plume Group
Control Alternative AC-3

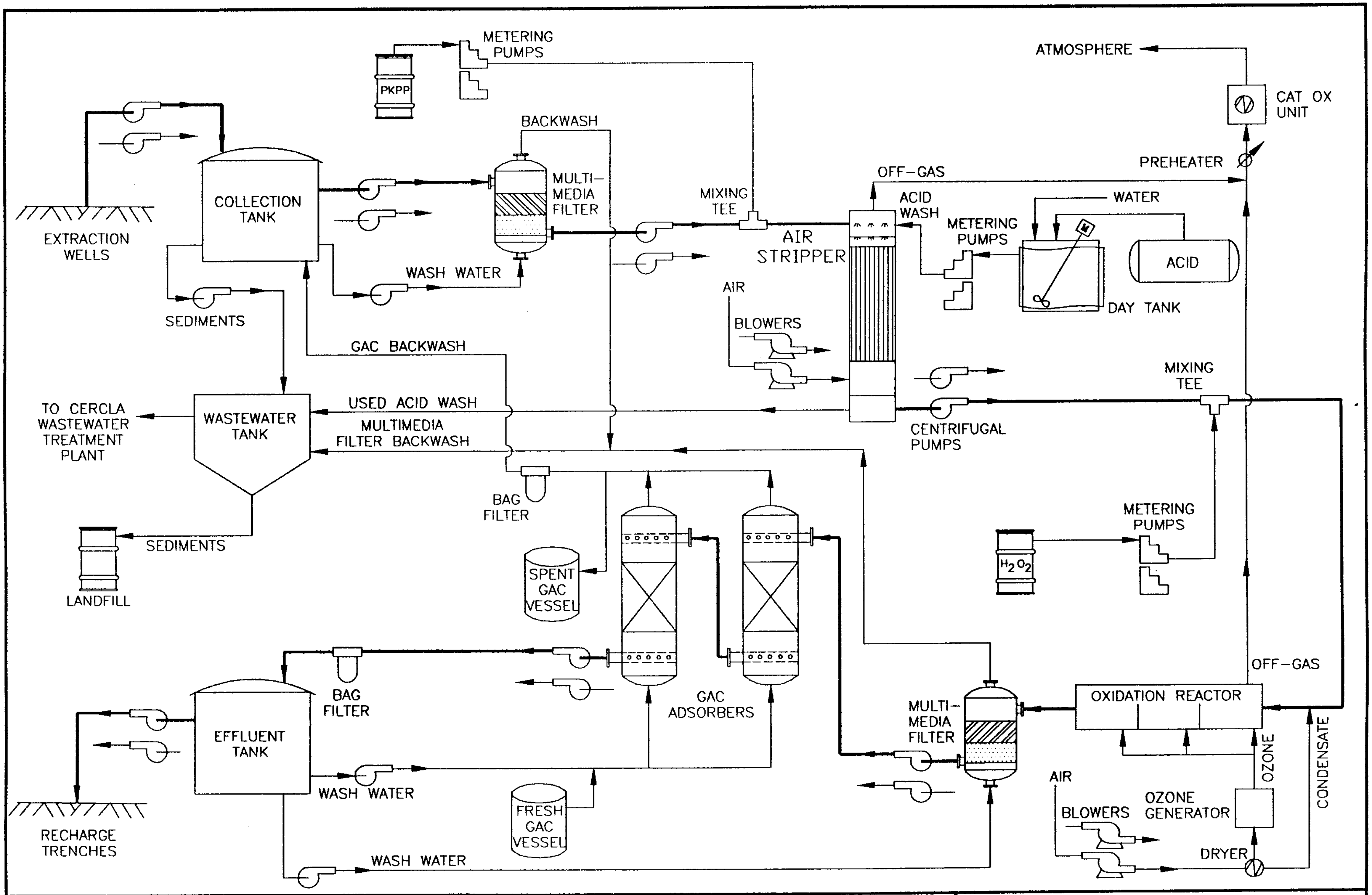
Prepared by:
EBASCO SERVICES INCORPORATED



Prepared for:
Office for the Program Manager
for Rocky Mountain Arsenal

FIGURE 7.3–2
Process Flow Diagram
Treatment Alternative AT–2,
Air Stripping/GAC Adsorption

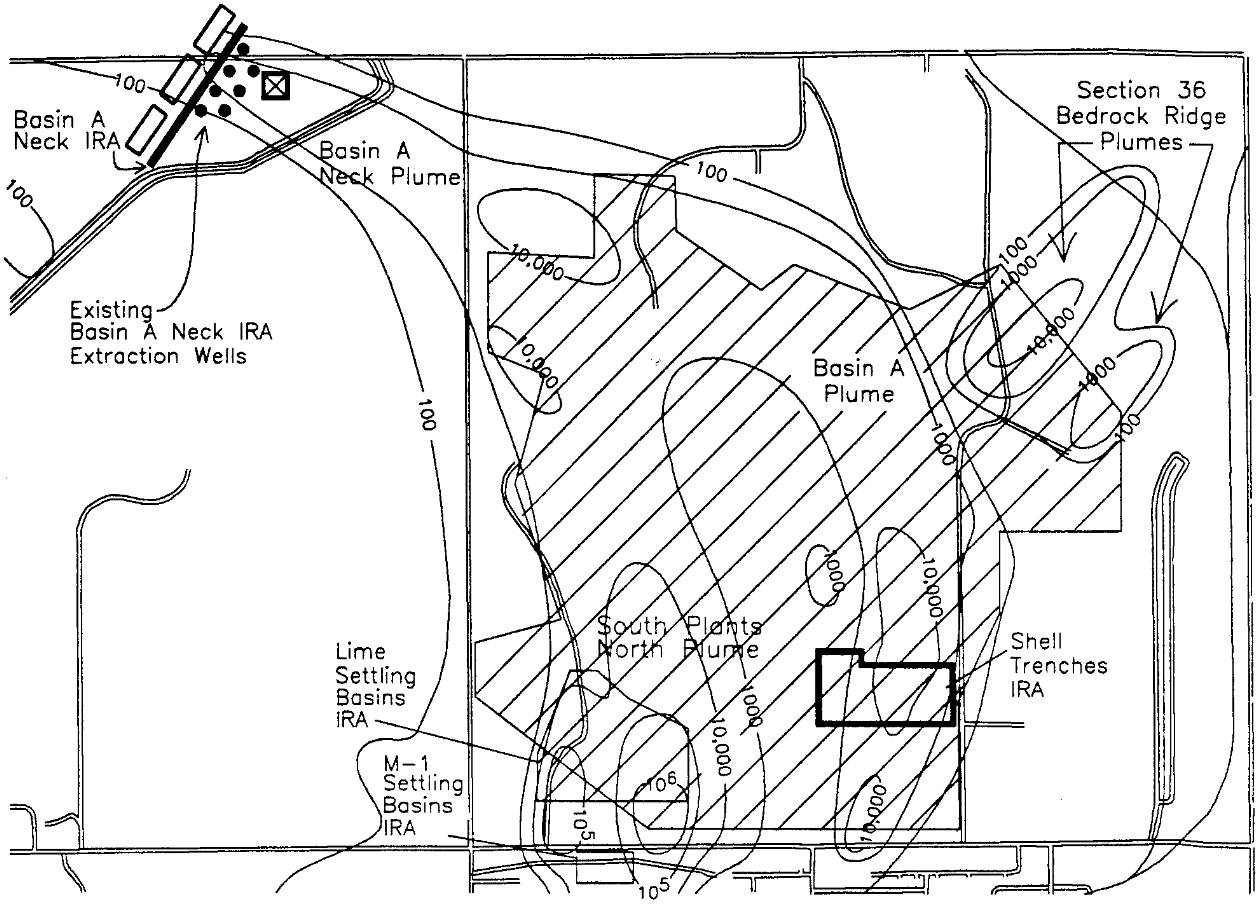
Prepared by:
Ebasco Services Incorporated



Prepared for:
Office for the Program Manager
for Rocky Mountain Arsenal

FIGURE 7.4-1
Process Flow Diagram
Treatment Alternative AT-4,
Air Stripping/Oxidation/GAC Adsorption

Prepared by:
Ebasco Services Incorporated



LEGEND

▨ Cap

—100— Summed Concentration of organic analytes (Table 3.1–2) in unconfined aquifer (ug/L)

● Extraction Well

▭ Recharge Trench

▬ Slurry Wall

☒ Treatment Plant

N

Not To Scale

SOURCE: Water DSA Plume Map

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 7.5–1

Schematic for Basin A Plume Group Control Alternative AC–7

Prepared by:
EBASCO SERVICES INCORPORATED

8.0 SOUTH PLANTS PLUME GROUP

Ten alternatives were retained for consideration in the Water DAA for the South Plants Plume Group. Most of these alternatives have been modified since the completion of the Water DSA based on new groundwater modeling results for the South Plants area that show much lower flow rates than those used in the Water DSA. One modification that impacts nearly all of the alternatives is that water is not to be extracted from the South Plants Southwest Plume because of the estimated low contaminant concentrations and flow rate. The remaining plumes, the South Plants North Source, South Plants Southeast, and South Tank Farm Plumes, are treated using a mass reduction and/or dewatering approach. The CERCLA Wastewater Treatment Plant may be used to treat the groundwater instead of constructing the Basin A/South Plants combined treatment plant designed for this plume group depending on the available capacity of the former at the time the latter plant is scheduled for construction. The CERCLA Wastewater Treatment Plant is designed to treat 15 gpm, with a maximum capacity of 30 gpm for operation in a semibatch mode. Its capacity, therefore, is not adequate for treatment of the second phase of Alternatives SPC-6 or SPC-7. A separate bioremediation system is also being considered in seven of the alternatives evaluated for the South Tank Farm Plume.

Alternatives SPC-3/SPT-2, SPC-3/SPT-3, SPC-3/SPT-2/SPT-4, and SPC-3/SPT-3/SPT-4 contain treatment systems that will be located in the same building as the Basin A treatment system, referred to as the Basin A/South Plants combined treatment plant. This plant will house both treatment trains under these alternatives. Under Alternatives SPC-5/SPT-5, SPC-6/SPT-2/SPT-5, SPC-6/SPT-3/SPT-5, SPC-7/SPT-2/SPT-5, and SPC-7/SPT-3/SPT-5 the groundwater extracted will be combined with that extracted from the Basin A Plume Group to be treated as discussed in Section 7, due to the low iron rate.

The primary contaminants present in the South Plants North Source and South Plants Southeast Plumes are chloroform, benzene, chlordane, and DBCP. The primary contaminant in the South Tank Farm Plume is benzene. These are the only contaminants that exceed the PECs, although other compounds are present at low concentrations, including the pesticide aldrin and the volatile

halogenated compounds carbon tetrachloride, tetrachloroethylene, and methylene chloride. Although the treatment systems are designed to meet DTGs, the maximum allowable effluent concentrations are represented by the TECs (which are twice the DTGs).

The South Tank Farm Plume is unique in that there are approximately 2,000 gallons of light nonaqueous phase liquid (LNAPL) associated with the plume. The recoverable LNAPL volume is likely to be lower since it is expected that a significant fraction cannot drain freely from the aquifer matrix. All treatment alternatives include removal of the LNAPL, which is composed of dicyclopentadiene (DCPD) with some benzene, using a dual-pump system (MKE 1992b). The LNAPL is currently planned to be drummed and sent off post for incineration, although no final decision as to treatment has been made. Appropriate treatment modifications will be made for any DNAPL encountered in the South Plants plumes.

The South Tank Farm Plume IRA, which involves groundwater monitoring, has been implemented in South Plants. Pilot-scale treatability studies involving removal of LNAPL are currently being conducted.

Those alternatives evaluated for the Basin A and South Plants Plume Groups that involve construction of a treatment facility assume that the same facility, referred to as the Basin A/South Plants combined treatment plant, is used for both plume groups. In Alternative SPC-5, and in Alternatives SPC-6 and SPC-7 for the first 10 years, the flow rate of the water extracted from the South Plants North Source and Southeast Plumes is 2 gpm. In these alternatives, the 2-gpm flow is combined with the Basin A Plume Group water to be treated as part of the Basin A Plume Group preferred alternative.

The following sections provide detailed descriptions and analyses for each of the ten alternatives retained from the Water DSA for the South Plants Plume Group. Table 8.0-1 presents a summary of the analyses. It should be noted that the O&M costs presented in this table represent

the highest O&M costs for that particular alternative when the costs differ between different time periods.

8.1 ALTERNATIVE SPC-1: NO ACTION

Alternative SPC-1 specifies that any current or future IRAs for the South Plants Plume Group be discontinued.

8.1.1 Description of Alternative

No groundwater control activities are performed under this alternative. The monitoring that is currently being performed for the South Tank Farm Plume IRA is terminated, and further treatability studies of the LNAPL plume are discontinued.

8.1.2 Analysis of Alternative

8.1.2.1 Overall Protection of Human Health and the Environment

Alternative SPC-1 does not prevent contamination from the South Plants area from migrating toward RMA boundaries. However, contaminated groundwater is captured and treated by the boundary systems and, therefore, does not pose an unacceptable threat to human health or the environment off post. The potential of contaminant migration from the South Plants Plume Group impacts the on-post environment.

8.1.2.2 Compliance with ARARs

Action-specific ARARs listed in the Technology Description Volume, Appendix A are not relevant if Alternative SPC-1 is chosen. This alternative complies with all potential chemical- and location-specific ARARs presented in Appendix A, Volume I of the Water DSA and with the FFA so long as the boundary systems continue to operate.

8.1.2.3 Long-Term Effectiveness and Permanence

Continued migration of contaminants from the source area in South Plants may eventually increase the loading on the boundary systems, which may require the implementation of boundary system upgrades. However, so long as the boundary systems achieve off-post PRGs and the FFA remains in place, this alternative is sufficiently effective. No groundwater controls are added as part of this alternative.

8.1.2.4 Reduction of TMV

This alternative involves no active extraction/treatment or the removal of existing controls. Contaminant mobility and toxicity of on-post plumes are likely to increase as a result of continued migration from the source area, which also results in a larger volume of contamination.

8.1.2.5 Short-Term Effectiveness

Implementation of Alternative SPC-1 has no impact on the environment, surrounding community, and workers. Since no controls are implemented, contamination is free to migrate to the boundary. RAOs are achieved so long as the boundary systems continue to operate.

8.1.2.6 Implementability

This alternative is technically and administratively feasible. It is easily implemented since no actions are undertaken or removed.

8.1.2.7 Costs

There is no capital cost associated with Alternative SPC-1. The annual O&M costs are $114,000, and the present worth cost is $1,800,000. A summary of costs is presented in Appendix A, Table A5-1.

8.2 ALTERNATIVE SPC-3/SPT-2: MASS REDUCTION, AIR STRIPPING/SORPTION

This alternative consists of groundwater extraction from the South Plants North Source, South Plants Southeast, and South Tank Farm Plumes. The contaminants are removed by extraction wells and LNAPL in the South Tank Farm Plume is separated. Extracted water is treated using air stripping and GAC adsorption and then is reinjected into two recharge trenches located in Section 27. This alternative is accomplished in conjunction with the preferred Basin A groundwater alternative and also with soils remedial activities, which include caps over Basin A and the South Plants Central Processing Area. Table 8.2-1 presents the estimated chemical influent concentrations for this alternative.

8.2.1 Description of Alternative

8.2.1.1 Extraction/Reinjection

As shown in Figure 8.2-1, this alternative consists of mass reduction systems located in the South Plants North Source, South Plants Southeast, and South Tank Farm Plumes that use five, three, and nine extraction wells, respectively. These systems operate for approximately 10 years. LNAPL in the South Tank Farm Plume is recovered by using a dual-pump system.

All extraction wells included in this alternative are constructed using 12-inch-diameter borings with gravel pack surrounding the 6-inch-diameter casing and screen (which increases the effective intake radius of the wells), and all pipelines are double walled unless otherwise noted. All wells have one-third horsepower submersible pumps installed in them and all booster pumps are 1.5 horsepower.

The mass reduction system located in the South Plants North Source Plume consists of five wells that extract a total of 1 gpm of groundwater. The wells are approximately 45 ft deep, with the screened portions penetrating the weathered Denver Formation. The submersible pumps installed in each well are connected to a collector manifold, which in turn is connected to a buried transport pipe. The water is pumped from a collection tank to the Basin A/South Plants

combined treatment plant. The total flow of 1 gpm may be combined with the water from the South Plants Southeast, South Tank Farm, and/or Basin A Plumes.

The water from the treatment plant is reinjected in two trenches located in permeable alluvium in the northwestern portion of Section 27. The recharge trenches are lined with geotextile filter fabric, backfilled with clean gravel, and covered with geotextile filter fabric and approximately 3 ft of soil. Well points are placed in the gravel during backfilling operations for even distribution of reinjected water. The trenches are constructed to ensure that water is recharged to the aquifer and that the vertical flow of recharged waste is not restricted by possible impermeable layers in the alluvium.

Groundwater is extracted from the South Plants Southeast Plume using a mass reduction system located in a linear orientation along the axis of the plume. The three extraction wells have the same design as described for the South Plants North Source Plume. Under this scenario, approximately 1 gpm of extracted groundwater is collected in a collector manifold connected to a tank. The water is then piped to the Basin A/South Plants combined treatment plant for treatment. The treated water is then transported through single-walled pipe to the reinjection trenches along with the treated water from the other plumes.

The mass reduction system located in the South Tank Farm Plume uses nine extraction wells spaced along the axis of the plume. The extraction wells, which have the same design as those for the other two plumes, pump approximately 6 gpm of groundwater to a collection tank. The water is then pumped by a 1.5-horsepower pump and transported to the proposed Basin A/South Plants combined treatment plant through double-walled pipe. The treated water is then piped to the same reinjection trenches discussed for Alternative AC-3/AT-2 (Section 7.3.1.1).

The LNAPL in the South Tank Farm Plume near Tank 464A is pumped out of the ground using a dual-pump system. The extraction of the LNAPL continues for a maximum of 5 years. The aqueous and organic phases are extracted separately. The low volume of water resulting from

the phase-separation process may be piped or transported by a tanker truck to the same treatment plant that treats the other South Plant plumes. The organic phase is drummed and stored for off-post transportation and incineration.

Groundwater-quality and water-level data from a monitoring network of existing plume evaluation and monitoring wells as well as newly installed performance monitoring wells are used to evaluate the effectiveness and operation of the extraction system. The final number and location of the new wells is based upon review of the existing wells.

8.2.1.2 Treatment

The treatment system for Alternative SPT-2 uses air stripping followed by GAC to remove contaminants from the groundwater. This system is part of the Basin A/South Plants combined treatment plant and is designed to accommodate 10 gpm. This treatment continues for 10 years based on volume the estimates of water removal needed to significantly reduce the contaminant mass in groundwater in the centers of the plumes. Figure 8.2-2 presents a process flow diagram showing the major pieces of treatment equipment as well as tanks, pumps, and filters used in this alternative.

Extracted water is stored in an equalization tank prior to being treated. The water is then pumped through a multimedia filter to remove suspended soils and a sequesterant is added to keep dissolved solids, such as calcium and iron, in solution. The water then enters the air stripper, which is 17 ft high and 1 ft in diameter. The air stripper is operated with an air/water ratio of 30 and is designed to remove 90 percent of the volatile organics from the groundwater. A more detailed description of the air stripping technology is presented in the Technology Description Volume, Section 14.3.

The organic contaminants in the air emissions from the air stripper are destroyed using a catalytic oxidation unit, which uses thermal energy in the presence of a catalyst to destroy the contaminants. Supplemental fuel is required to completely oxidize the organics. In addition, the

catalyst must be replaced every 3 to 5 years, and is usually returned to the vendor where the catalyst (platinum) is recovered.

Over time, the packing in the air stripper becomes fouled by the deposition of inorganic complexes. When this occurs, the stripper is shut down and the packing and mist eliminator are washed with an acid solution. The acid rinse is returned to a wastewater tank.

The water effluent from the air stripper is pumped to the GAC adsorbers. GAC treatment is accomplished using two fixed-bed GAC adsorbers that are connected in series and operated in downflow mode. Each vessel is 12 ft high, 4 ft in diameter, and holds 2,000 lbs of carbon. The GAC adsorbers are designed to remove in excess of 95 percent of the DBCP, OCPs, and remaining volatiles. Estimated carbon consumption is 12,000 lbs per year. When the lead carbon vessel reaches an unacceptable pressure drop due to clogging of the carbon, the vessel is removed from service and backwashed with water from the effluent tank to remove particulates and re-expand the carbon bed. The backwash water is filtered and returned to the collection tank. A more detailed description of the GAC treatment technology is included in the Technology Description Volume, Section 14.2.

When the lead vessel becomes saturated with contaminants, it is taken offline and the carbon is replaced. Spent carbon is transferred to a storage vessel to await collection by the vendor and new carbon is transferred into the empty adsorber. The order of the vessels in the series is reversed so that the partially saturated adsorber becomes the lead vessel.

The GAC effluent is run through a bag filter to remove carbon fines and suspended solids and is collected in a holding tank, which allows for a 4-hour shutdown of the reinjection system for maintenance purposes.

8.2.1.3 Sidestreams

This treatment system produces two major sidestreams, vapor emissions from the air stripper and spent GAC from the adsorbers. In addition, smaller streams such as wastewater, which includes the acid wash from the air stripper and backwash water from the multimedia filters, as well as used bags from the filters, are generated.

The vapor-phase emissions from the air stripper are treated with catalytic oxidation. Because this process actually destroys the contaminants instead of transferring them to another medium, no further treatment of the vapor-phase emissions is required.

The acid wash for the air stripper packing is neutralized in the wastewater tank. It is anticipated that the packing must be replaced once a year. If the packing can be decontaminated, it is sent to a sanitary landfill; if not, it is sent to the on-post hazardous waste landfill. The spent carbon from the GAC units is collected by the vendor supplying the carbon and is thermally regenerated off post.

Used bags from filters require disposal. Because they have been in contact with hazardous materials, they are drummed and transported to the on-post hazardous landfill as described in Section 6.5 of the Technology Description Volume. The wastewater in the wastewater tank is sent to the CERCLA Wastewater Treatment Plant and the sediments from the wastewater tank are drummed and landfilled.

8.2.2 Analysis of Alternative

8.2.2.1 Overall Protection of Human Health and the Environment

Alternative SPC-3/SPT-2 removes chloroform, benzene, DBCP, OCPs, and LNAPL, achieving a reduction in the contaminant mass and potentially reducing loading on the boundary systems over time.

A significant fraction of the contaminant mass is permanently removed from the centers of the plumes in the first 10 years based on calculations of contaminant mass removed. This decreases the toxicity of contaminants in the groundwater and reduces migration of the contaminants. Contaminants that are not removed by this alternative are effectively removed to acceptable levels by the boundary systems, reducing the risks of exposure to human health and the environment. Continued monitoring after 10 years of control and treatment assesses whether contaminant concentrations of the groundwater have been permanently reduced. Provisions of the FFA ensure that groundwater contamination does not migrate off post and that of on-post water is not used as potable water.

Once extraction and treatment is completed and the extraction systems are discontinued, any remaining contaminants are free to migrate. These contaminants should occur at low levels that are expected to be further reduced through natural attenuation.

8.2.2.2 Compliance with ARARs

This remedial alternative is in compliance with all potential action-specific ARARs listed in the Technology Description Volume, Appendix A, including those related to the extraction systems and air emission controls, because it involves extraction well systems and groundwater treatment systems that comply with these ARARs. Recovery, transportation, and off-site treatment of LNAPL from the South Tank Farm Plume comply with these potential action-specific ARARs. The treatment systems also comply with all potential chemical-specific ARARs listed in Appendix A, Volume I of the Water DSA, and with the FFA. PRGs are achieved at the RMA boundary through continued operation of the boundary systems. Operation of the extraction well systems and continued operation of the boundary systems, along with appropriate siting of the Basin A/South Plants combined treatment plant, ensures compliance with all potential location-specific ARARs applicable to groundwater which are listed in Appendix A, Volume I of the Water DSA.

8.2.2.3 Long-Term Effectiveness and Permanence

This alternative reduces the magnitude of residual risks by permanently removing contamination from the groundwater. The potential for off-post exposure is reduced through mass removal from the South Plants North Source, South Plants Southeast, and South Tank Farm Plumes in conjunction with continuing operation of the boundary systems.

Contaminants are removed and treated close to the source. The boundary systems ensure that any groundwater that is not captured and treated on post meets PRGs at the RMA boundaries. Monitoring occurs during the operation of the treatment system and continues once the system is shut down in order to evaluate long-term effectiveness and plume migration.

8.2.2.4 Reduction of TMV

This alternative reduces toxicity and mobility of contaminants in the groundwater by removing and treating of significant contaminant mass from the centers of the plumes. Under this alternative, air stripping removes the majority of the volatile organics, and GAC adsorption treats the remaining organic contaminants to the TECs. LNAPL is separated from the South Tank Farm Plume using a dual-pump system, is drummed, and then incinerated off post. Toxicity is reduced by removing contaminants from the groundwater prior to reinjection.

A mass reduction system extracts the groundwater at the source, reducing the potential for migration through the aquifer. The lowering of the water table reduces the amount of contaminants in the soil that are in contact with the groundwater. In this system, 8 gpm are extracted from the South Plants North Source, South Plants Southeast, and South Tank Farm Plumes. Over a 5-year period, up to 2,000 gallons of LNAPL are also removed and incinerated off post. These systems result in a decrease of contaminant mobility in the South Plants Plume Group.

The contaminants are irreversibly transferred from the groundwater to the vapor phase by air stripping and are subsequently destroyed by catalytic oxidation. Contaminants treated with GAC

adsorption are transferred to the carbon, which is thermally regenerated off post. Any contaminants that are not intercepted by the extraction system or any contaminants that remain sorbed to the soil in the aquifer and desorb at a later time are treated by the boundary systems if they migrate to the boundary.

8.2.2.5 Short-Term Effectiveness

In general, the construction, operation, and final demobilization of this alternative have minimal negative impact on the environment, workers, and the surrounding community. On-post workers are potentially exposed to contaminants through dermal contact and dust inhalation during excavation and well and trench installation. To reduce the potential for such exposure, dust control measures and PPE are used.

Operators of the system must also concern themselves with proper chemical-handling techniques when washing the stripper packing with sulfuric acid. To reduce the potential for exposure, personnel are made aware of health and safety procedures and PPE is used.

RAOs are achieved for this alternative. The estimated time for significant reduction of contaminant mass is approximately 10 years (Section 3.2.3).

8.2.2.6 Implementability

This alternative is technically feasible. Extraction/reinjection systems, water transport systems, air stripping, and GAC adsorption are proven and readily available technologies. As discussed in the Technology Descriptions Volume (Sections 5, 14.3, and 14.2), these technologies are currently being used at RMA. All equipment required is commercially available. The extraction system incorporates existing wells where possible. The operators do not require any more training for operation of this alternative than for existing systems at RMA.

The alternative is expected to be reliable. The system requires minimal down time for equipment maintenance; in many cases, maintenance can be performed without shutting down the entire

system. The system has automated controls that ensure continuous operation with little supervision.

GAC and air stripper packing are readily available and supplied in sufficient quantities by qualified vendors. Spent carbon is transported off post and regenerated by vendors. The sludge containing inorganics is stabilized and disposed, along with bag filters, in the on-post landfill. Precious metals are recycled from the spent catalyst by the supply vendor.

Administratively, this alternative is easily implementable. It requires an operation and maintenance program for the treatment system, contracts with GAC suppliers, vendors who manage hazardous waste, and the performance of periodic site monitoring and 5-year reviews.

8.2.2.7 Cost

The capital cost of this treatment system is estimated at $3,730,000. Approximate annual O&M costs, including monitoring, for years 1 to 5 (while the LNAPL removal system operates) are $693,000 and for years 6 to 10 are $683,000. The annual O&M costs for the remaining 20 years, including monitoring, are $152,000. The present worth cost for 30 years of operation is estimated at $10,500,000. A cost summary is presented in Appendix A, Table A5-2.

8.3 ALTERNATIVE SPC-3/SPT-3: MASS REDUCTION, OXIDATION/SORPTION

This alternative consists of groundwater extraction from the South Plants North Source, South Plants Southeast, and South Tank Farm Plumes. Extraction is completed in a mass reduction configuration and LNAPL in the South Tank Farm Plume is separated using a dual-pump system. Extracted water is treated with oxidation and GAC adsorption and is then reinjected into two recharge trenches in Section 27. This alternative differs from Alternative SPC-3/SPT-2 (stripping/sorption) in the treatment of the extracted water (oxidation/sorption). Table 8.2-1 presents the estimated chemical influent concentrations for this alternative.

8.3.1 Description of Alternative

8.3.1.1 Extraction/Reinjection

This alternative includes the same groundwater control systems that are used for Alternative SPC-3/SPT-2 (Section 8.2.1.1).

8.3.1.2 Treatment

The treatment system for Alternative SPT-3 uses oxidation followed by GAC to remove contamination from the groundwater. The design capacity of the system is 10 gpm. This treatment continues for 10 years based on volumetric estimates of water removal needed to significantly reduce the contaminant mass in groundwater in the plume centers. Figure 8.3-1 presents a process flow diagram showing the major pieces of treatment equipment as well as tanks, pumps, and filters used in this alternative.

Extracted water is collected in a tank prior to being treated. Hydrogen peroxide is added through a mixing tee and the water is filtered to remove the iron and manganese that may precipitate as a result of the hydrogen peroxide addition. The filtered water is then pumped to the oxidation reactor. Ozone, produced from air with an ozone generator, is injected into the reactor. The oxidation reactor is designed to destroy more than 90 percent of the volatile organics, OCPs, and DBCP in the groundwater during a retention time of 30 minutes. A more detailed description of this technology is included in the Technology Description Volume, Section 14.1.

Treated water exiting the oxidation reactor is pumped to the GAC adsorbers. Prior to introduction to the GAC adsorbers, the treated water is filtered to remove any solids that precipitated in the oxidation step. The GAC adsorption system used in this alternative is the same as that used for Alternative SPC-3/SPT-2, which is described in Section 8.2.1.2. The GAC adsorbers are designed to remove in excess of 95 percent of the remaining DBCP, OCPs, and volatile organics. The estimated carbon consumption for this alternative is 3,100 lbs per year. A more detailed description of the GAC treatment technology is included in the Technology Description Volume, Section 14.2.

The GAC effluent is filtered through a bag filter to remove carbon fines and suspended solids and is collected in a holding tank, which allows for a 4-hour shutdown of the reinjection system for maintenance purposes.

8.3.1.3 Sidestreams

This treatment system produces two major sidestreams, vapor emissions from the oxidation reactor and spent carbon from the adsorbers. In addition, smaller streams such as wastewater, which includes backwash water from the multimedia filters and used bags from the filters, are generated.

The vapor-phase emissions from the oxidation reactor are treated with catalytic oxidation. Because this process actually destroys the contaminants instead of transferring them to another medium, no further treatment of the vapor-phase emissions are required.

Spent carbon is collected by the vendor and is thermally regenerated off post. Used bags from filters require disposal. Because the filters have been in contact with hazardous materials, they are drummed and sent to the on-post hazardous waste landfill as described in the Technology Description Volume, Section 6.5. The wastewater in the wastewater tank is sent to the CERCLA Wastewater Treatment Plant and the sediments from the wastewater tank are drummed and landfilled.

8.3.2 Analysis of Alternative

8.3.2.1 Overall Protection of Human Health and the Environment

Alternative SPC-3/SPT-3 removes chloroform, benzene, DBCP, and LNAPL, reducing the mass of contaminants in the groundwater and potentially reducing loading on the boundary systems.

A significant fraction of the contaminant mass is permanently removed from the centers of the plumes in the first 10 years based on calculations of the quantity of contaminant mass removed, which reduces the migration of the contaminants. Continued monitoring after 10 years of

treatment assesses whether the contaminant concentrations in the groundwater have been permanently reduced. Contaminants that are not removed by this alternative are effectively removed to acceptable levels by the boundary systems, reducing the risks of exposure to human health and the environment. Restrictions on the future uses of groundwater at RMA further reduce the potential for on-post exposure.

Once extraction and treatment is completed and extraction systems are discontinued, any remaining contaminants are free to migrate. These contaminants should occur at low levels that are expected to be further reduced through natural attenuation, and be intercepted should they migrate to the boundary systems.

8.3.2.2 Compliance with ARARs

This remedial alternative is in compliance with all potential action-specific ARARs listed in the Technology Description Volume, Appendix A, including those related to the extraction systems and air emission controls, because it involves extraction well technology and groundwater treatment technologies that comply with these ARARs. Recovery, transportation, and off-post treatment of LNAPL from the South Tank Farm Plume complies with these potential ARARs. The treatment systems also comply with all potential chemical-specific ARARs listed in Appendix A, Volume I of the Water DSA, and with the FFA. PRGs are achieved at the RMA boundary through continued operation of the boundary systems. Along with appropriate siting of the Basin A/South Plants combined treatment plant, this ensures compliance with all potential location-specific ARARs applicable to groundwater, which are listed in Appendix A of the Water DSA.

8.3.2.3 Long-Term Effectiveness and Permanence

This alternative reduces the magnitude of residual risks by permanently removing contamination from the groundwater. The potential for off-post exposure is reduced by the additional mass removal and treatment system in conjunction with the boundary systems.

Contaminants are removed and treated at the source. The boundary systems ensure that any groundwater that is not captured on post meets PRGs at the RMA boundary. Monitoring occurs during the operation of the treatment system and continues once the system is shut down to evaluate long-term effectiveness and plume migration.

8.3.2.4 Reduction of TMV

This alternative reduces toxicity and mobility of contaminants in the groundwater by removing of significant contaminant mass from the centers of the plumes and treating of the contaminants. The groundwater extracted from the South Plants North Source, South Plants Southeast, and South Tank Farm Plumes is treated by a combination of oxidation and GAC adsorption. Oxidation destroys a large fraction of the contaminants and volatilizes a fraction of the volatile organics, and GAC adsorption treats the remaining organic contaminants to the TECs. LNAPL is separated from the South Tank Farm Plume, drummed, and incinerated off post. Toxicity is reduced by the removal of the contaminants from the groundwater prior to reinjection.

A mass reduction system extracts the groundwater at the source, reducing the potential for migration through the aquifer. The lowering of the water table reduces the amount of contaminants in the soil that are in contact with groundwater, reducing the potential for contaminants to desorb into the groundwater. In this system, 8 gpm is extracted from the South Plants North Source, South Plants Southeast, and South Tank Farm Plumes. Over a 5-year period, up to 2,000 gallons of LNAPL are removed and incinerated off post. These systems result in the decrease of contaminant mobility in the South Plants Plume Group.

The contaminants are irreversibly destroyed or volatilized by oxidation or transferred from the groundwater to GAC by adsorption. The organics in the vapor emissions generated by the oxidation reactor are destroyed by catalytic oxidation. The spent carbon requires regeneration. Any contaminants that are not intercepted by the extraction system or any contaminants that remain sorbed to the soil in the aquifer and desorb at a later time are treated by the boundary systems if they migrate to the boundaries of RMA.

Since the contaminants in the South Plants plumes are removed from the groundwater prior to reinjection, the treatment is irreversible. Some contaminants remain in the South Plants plumes because a fraction of the flow containing contaminants may not be removed by the extraction system and because some contaminants may remain sorbed to the soil in the aquifer and desorb at a later time.

8.3.2.5 Short-Term Effectiveness

In general, the construction, operation, and final demobilization of this alternative has minimal negative impact on the environment, workers, and the surrounding community. On-post workers are potentially exposed to contaminants by dermal contact and dust inhalation during excavation and well and trench installation. To reduce the potential for such exposure, dust control measures and PPE are used.

The oxidation reactor requires ozone, a toxic gas, which must be constantly monitored, and the handling of contaminated GAC associated with changeout may present a concern for workers. To reduce the potential for exposure, personnel are made aware of health and safety procedures and PPE is used.

RAOs are achieved under this alternative. The estimated time frame required for significant reduction of contaminant mass is approximately 10 years, based on the average volumetric estimates.

8.3.2.6 Implementability

This alternative is technically feasible. Extraction/reinjection systems, water transport systems, and GAC adsorption are proven and readily available technologies. As discussed in the Technology Description Volume (Sections 5 and 14.2), these technologies are currently being used at RMA. The advanced oxidation process, using hydrogen peroxide and ozone, is an innovative technology (Technology Description Volume, Section 14.1). Pilot-scale studies may

be required as follow up to the U.S. Army Corps of Engineers WES bench-scale treatability studies (Zappi 1993) to ensure its implementability.

All equipment required for this alternative is commercially available from several vendors, with the exception of oxidation, for which a limited number of vendors supply the equipment. The extraction system incorporates existing wells where possible. The operators require further training for operation of oxidation reactors.

The alternative is expected to be reliable. The system requires minimal down time for equipment maintenance; in many cases, maintenance can be performed without shutting down the entire system. The system has automated controls that ensure continuous operation with little supervision.

GAC, produced and supplied in sufficient quantities by qualified vendors, is transported and regenerated by the vendors as part of the supply contract. The sludge containing inorganics is stabilized and disposed, along with bag filters, in the on-post RCRA landfill. Precious metals are recovered from spent catalyst by the supply vendor.

Administratively, this alternative is easily implementable. It requires an operation and maintenance program for the treatment system, contracts with GAC suppliers, vendors who manage hazardous waste, periodic site monitoring, and 5-year reviews.

8.3.2.7 Cost

The capital cost of this treatment system is estimated at $4,090,000. Approximate annual O&M costs, including monitoring, for years 1 to 5 (while the LNAPL system operates) are $650,000 and for years 6 to 10 are $639,000. The annual O&M costs for the remaining 20 years, including monitoring, are $152,000. The present worth cost for 30 years of operation is estimated at $10,500,000. A cost summary is presented in Appendix A, Table A5-3.

8.4 ALTERNATIVE SPC-3/SPT-2/SPT-4: MASS REDUCTION, AIR STRIPPING/SORPTION, BIOLOGICAL REACTOR/SORPTION

This alternative consists of groundwater extraction from the South Plants North Source, South Plants Southeast, and South Tank Farm Plumes. Extraction is completed in a mass reduction configuration and LNAPL in the South Tank Farm Plume is separated by using a dual-pump system. Extracted water from the South Plants North Source and South Plants Southeast Plumes is treated using air stripping and GAC adsorption and is then reinjected into two recharge trenches located in Section 27. Extracted water from the South Tank Farm Plume is treated in a biological reactor and then by GAC adsorption. This alternative differs from Alternative SPC-3/SPT-2 in that the South Tank Farm Plume is treated separately instead of being combined with the South Plants North Source and South Plants Southeast Plumes. This alternative is accomplished in conjunction with soils and structures remedial activities. Table 8.4-1 presents the estimated chemical influent concentrations for the South Plants North Source and South Plants Southeast Plumes. Table 8.4-2 presents the estimated chemical influent concentrations for the South Tank Farm Plume.

8.4.1 Description of Alternative

8.4.1.1 Extraction/Reinjection

This alternative includes the same groundwater control systems that are used for Alternative SPC-3/SPT-2 (Section 8.2.1.1), except that the water extracted from the South Tank Farm Plume is treated separately in a biological reactor.

8.4.1.2 Treatment

The treatment system for Alternative SPT-2/SPT-4 uses air stripping followed by GAC to remove contamination from the South Plants North Source and South Plants Southeast Plumes. This system is identical to the one for Alternative SPC-3/SPT-2, which is described in Section 8.2.1.2, but is designed to treat 5 gpm. Figure 8.2-2 presents a process flow diagram showing the major pieces of treatment equipment as well as tanks, pumps, and filters used in this part of the alternative. Water extracted from the South Tank Farm Plume is treated in a biological reactor

to remove most of the benzene and is then combined with the flow from the South Plants North Source and South Plants Southeast Plumes as it enters the GAC adsorbers, where the remaining benzene is treated (Figure 8.4-1). The GAC adsorbers shown in Figure 8.4-1 are identical to the ones shown in Figure 8.2-2. The treatment plant referred to in the following paragraphs is part of the facility that is used to treat water extracted from Basin A (Basin A/South Plants combined treatment plant).

Water from the South Tank Farm Plume is extracted at a rate of 5 gpm and is treated in a biological reactor, with GAC as the support medium, to remove more than 80 percent of the benzene. Extracted water is pumped to an influent holding tank before being transferred to a reactor tank filled with 670 lbs of GAC (to which the biofilm adheres). A recycle pump is included to support a 23-gpm recycled flow through the reactor tank. A chemical tank and pump are also included to provide nutrients for microorganism growth. In addition, an oxygenator supplies 2 lbs of oxygen to the tank each day. The retention time for the reactor is 40 minutes. Effluent from the reactor is pumped to the GAC units used to treat the South Plants North Source and South Plants Southeast Plume groundwater.

8.4.1.3 Sidestreams

This treatment system produces two major sidestreams; vapor emissions from the air stripper and spent carbon, as well as smaller sidestreams such as the acid wash from the air stripper and used bags from the filters as described in Section 8.2.1.3.

8.4.2 Analysis of Alternative

8.4.2.1 Overall Protection of Human Health and the Environment

Removal of the VHOs, benzene, DBCP, OCPs, and LNAPL from the groundwater in the South Plants North Source and South Plants Southeast Plumes and biodegradation of the benzene in the South Tank Farm Plume results in a reduction in the contaminant mass in the environment.

The permanent removal of the contaminants reduces the contaminant load in the groundwater and reduces the migration of the contaminants. A significant fraction of the contaminant mass is removed from the centers of the plumes in the first 10 years based on volumetric calculations of the quantity of contaminant mass removed.

Once extraction and treatment is completed and the extraction systems are discontinued, any remaining contaminants are free to migrate. The contaminants should be present at low levels that are expected to be further reduced by natural attenuation and be intercepted should they migrate to the boundary systems.

8.4.2.2 Compliance with ARARS

This remedial alternative is in compliance with all potential action-specific ARARs listed in the Technology Description Volume, Appendix A, including those related to the extraction systems and air emission controls, because it involves extraction well systems and groundwater treatment systems that comply with these ARARs. Recovery, transportation, and off-post treatment of LNAPL from the South Plant Tank Farm Plume complies with these potential ARARs. The treatment systems also comply with all potential chemical-specific ARARs listed in Appendix A of the DSA Water, and with the FFA. PRGs are achieved at the RMA boundary through continued operation of the boundary systems. Operation of the extraction well systems and continued operation of the boundary systems, along with appropriate siting of the common groundwater treatment facility, ensure compliance with all potential location-specific ARARs applicable to groundwater, which are listed in Appendix A, Volume I of the Water DSA, and with the FFA.

8.4.2.3 Long-Term Effectiveness and Permanence

This alternative reduces the potential for off-post exposure by removing and treating contaminants at the source. Direct biotreatment of the South Tank Farm Plume ensures that benzene levels are significantly and permanently reduced. The mass removal of contaminants reduces the potential for increased loading at the boundary systems. Any remaining contaminants either

biodegrade naturally or are removed by the boundary systems. Groundwater monitoring continues to evaluate long-term effectiveness and plume migration.

8.4.2.4 Reduction of TMV

This alternative reduces the TMV of contaminated groundwater by mass removal of the contaminants with extraction wells at the centers of the plumes. The groundwater intercepted at the South Plants North Source and South Plants Southeast Plumes is treated by a combination of air stripping and GAC adsorption at a rate of 5 gpm. Air stripping transfers volatile organics from the water phase to the vapor phase where they are subsequently destroyed by catalytic oxidation. Residual contaminants (OCPs, DBCP, and volatile organics) in the water are adsorbed onto GAC. Saturated GAC requires off-post thermal regeneration.

Direct biotreatment of the South Tank Farm Plume groundwater at 5 gpm significantly reduces the toxicity and volume of contaminants, thereby further reducing contaminant migration from the South Tank Farm area. LNAPL is separated and collected for analysis and eventual off-post incineration.

Since the contaminants in the South Plants plumes are removed from the groundwater prior to reinjection, the treatment is irreversible. Some contaminants remain in the South Plants plumes because a fraction of the flow containing contaminants may not be removed by the extraction system, and because some contaminants may remain sorbed to the soil in the aquifer and desorb at a later time.

8.4.2.5 Short-Term Effectiveness

In general, the construction, operation, and final demobilization of this alternative have minimal negative impact on the environment, workers, and the surrounding community. On-post workers are potentially exposed to contaminants through dermal contact and by dust inhalation during excavation and water extraction when constructing the recharge trenches. To minimize or prevent such exposure, dust control measures and PPE are used. The GAC system and the bioreactor

require periodic changeout of the spent carbon. To reduce potential exposure, personnel are made aware of health and safety procedures and PPE is used.

RAOs are achieved under this alternative. The estimated time frame for significant reduction of contaminant mass is approximately 10 years based on the average volumetric estimate.

8.4.2.6 Implementability

With the exception of the fluidized-bed reactor proposed for direct biological treatment, this alternative is composed of well-developed technologies: extraction/reinjection wells and trenches, air stripping, GAC adsorption and catalytic oxidation. As discussed in the Technology Description Volume (Sections 5, 14.3, 14.2, and 15), these technologies are all being used successfully at RMA. The equipment required is commercially available from several vendors. The extraction systems use existing wells supplemented with additional new wells. The water treatment system can be assembled on skids prior to shipment to the site. Startup and training can be performed in an acceptable period of time, and operators at RMA already have experience with most of the components of this system.

The alternative is expected to be reliable. The system allows temporary maintenance to be performed with minimal impacts to the schedule of operation. In many cases, maintenance can be performed without shutting down the system. The biotreatment system requires close oversight and additional training for the operators. Startup of this operation requires more time, but it can be brought online separately from the remainder of the treatment train. The system has automated controls that ensure continued operation with little supervision.

GAC and air stripper packing are produced and supplied in sufficient quantities by qualified vendors who are responsible for the transportation and regeneration of spent carbon. The sludge containing inorganics is stabilized and disposed, along with bag filters, in the on-post RCRA landfill. Precious metals are recovered from spent catalyst by the supply vendor. The groundwater and the treatment system are monitored during and after extraction/treatment.

8.4.2.7 Cost

The capital cost of this treatment system is estimated to be $4,390,000. Approximate annual O&M costs, including monitoring, for years 1 to 5, which includes LNAPL treatment, is $820,000. The annual O&M costs for years 6 to 10, including monitoring, are $810,000. The annual O&M costs for years 11 to 30, including monitoring, are $152,000. The net present worth cost of the entire remedial alternative is $12,200,000. A summary of costs is presented in Appendix A, Table A5-4.

8.5 ALTERNATIVE SPC-3/SPT-3/SPT-4: MASS REDUCTION, OXIDATION/SORPTION, BIOLOGICAL REACTOR/SORPTION

This alternative consists of groundwater extraction from the South Plants North Source, South Plants Southeast, and South Tank Farm Plumes. Extraction is completed in a mass reduction configuration and LNAPL in the South Tank Farm Plume is separated by using a dual-pump system. Extracted water from the South Plants North Source and South Plants Southeast Plumes is treated with oxidation and GAC adsorption and is then reinjected into recharge trenches in Section 27. Extracted water from the South Tank Farm Plume is treated first in a biological reactor and then by GAC adsorption. This alternative differs from Alternative SPC–3/SPT–2/SPT–4 only in that the extracted water from the South Plants North Source and South Plants Southeast Plumes is treated by oxidation/sorption instead of stripping/sorption. Table 8.4-1 presents the estimated chemical influent concentrations for the South Plants North Source and South Plants Southeast Plumes, and Table 8.4-2 the estimated chemical influent concentrations for the South Tank Farm Plume.

8.5.1 Description of Alternative

8.5.1.1 Extraction/Reinjection

This alternative includes the same groundwater control systems that are used for Alternative SPC-3/SPT-2 (Section 8.2.1.1). Extracted water is treated in two different treatment trains; therefore, the water from the South Tank Farm Plume is piped to a separate collection tank.

8.5.1.2 Treatment

The treatment system included in Alternative SPT-3/SPT-4 uses oxidation followed by GAC to remove contamination from the South Plants North Source and South Plants Southeast Plumes at the rate of 5 gpm. In addition, LNAPL is recovered from the South Tank Farm Plume and treated by off-post incineration. Water, extracted from the South Tank Farm Plume at the rate of 5 gpm, is treated in a biological reactor to remove most of the benzene; the remaining benzene is treated by GAC adsorption. Figure 8.4-1 presents a process flow diagram showing the major pieces of treatment equipment as well as tanks, pumps, and filters used in this alternative.

Extracted water is stored in a collection tank prior to being pumped to the UV/hydrogen peroxide oxidation reactor. Prior to reaching the reactor, hydrogen peroxide is added to the water as an oxidant and a precipitating agent for inorganics and the water passed through a multimedia filter to remove the iron and manganese precipitated by the hydrogen peroxide. The oxidation reactor uses UV light as well as the hydrogen peroxide to break down organics—primarily DBCP, chloroform, and benzene. The reactor has a retention time of 30 minutes and destroys 90 percent of the contamination. A more detailed description of this treatment technology is included in the Technology Description Volume, Section 14.1.

Effluent from the oxidation reactor is filtered to remove any solids precipitated and pumped to the GAC adsorbers. GAC treatment is accomplished using the same system as described for Alternative SPC-3/SPT-2 (Section 8.2.1.2). The GAC adsorbers are designed to remove in excess of 95 percent of the OCPs and remaining volatile organics. Estimated carbon consumption is 780 lbs per year. A more detailed description of the GAC treatment technology is also included in the Technology Description Volume, Section 14.2.

The GAC effluent is run through a bag filter to remove carbon fines and suspended solids and is collected in a holding tank, which allows for a 4-hour shutdown of the reinjection system for maintenance.

Water extracted from the South Tank Farm Plume is treated in the bioreactor described in Alternative SPC-3/SPT-2/SPT-4 (Section 8.4.1.2). Effluent from the reactor is pumped to the GAC units described for this alternative and then flows through a bag filter for removal of carbon particles prior to discharge to the effluent tank.

8.5.1.3 Sidestreams

This treatment system produces spent carbon, which is collected by the vendor supplying the carbon and is thermally regenerated off post. Used bags from filters require disposal. Because they have been in contact with hazardous materials, they are drummed and transported to the on-post hazardous waste landfill as described in the Technology Description Volume, Section 6.5. The sediments from the filter backwash are drummed and landfilled. The wastewater from the wastewater tank is sent to the CERCLA Wastewater Treatment Plant.

8.5.2 Analysis of Alternative

8.5.2.1 Overall Protection of Human Health and the Environment

Removal of the VHOs, benzene, DBCP, OCPs, and LNAPL from the groundwater in the South Plants North and South Plants Southeast Plumes and biodegradation of the benzene in the South Tank Farm Plume results in a reduction in the contaminant mass in the environment. The permanent removal of the contaminants reduces the volume and toxicity of the contaminated groundwater and reduces the migration of the contaminants. A significant fraction of the contaminant mass is removed from the centers of the plumes in the first 10 years based on the volumetric calculations of the contaminant mass removed. Continued monitoring after the demobilization of the treatment system assesses whether 10 years of treatment has permanently reduced the contaminant concentrations of the groundwater.

Once the mass reduction phase is completed and the extraction systems are discontinued, any remaining contaminants are free to migrate. The contaminants should be at low levels that may be further reduced by natural attenuation, and be intercepted should they migrate to the boundary systems.

8.5.2.2 Compliance with ARARS

This remedial alternative is in compliance with all potential action-specific ARARs listed in Appendix A of the Technology Description Volume, including those related to the extraction systems and air emission controls, because it involves extraction well systems and treatment systems that comply with these ARARs. Recovery, transportation, and off-post treatment of LNAPL from the South Tank Farm Plume also comply with these potential ARARs. The treatment systems also comply with all potential chemical-specific ARARs listed in Appendix A of the Water DSA, and with the FFA. PRGs are achieved at the RMA boundary through continued operation of the boundary systems. Operation of the extraction well systems and continued operation of the boundary systems, along with appropriate siting of the common groundwater treatment facility, ensure compliance with all potential location-specific ARARs applicable to groundwater, which are listed in Appendix A, Volume I of the Water DSA, and with the FFA.

8.5.2.3 Long-Term Effectiveness and Permanence

This alternative reduces the potential for off-post exposure by removing and treating contaminants at the source. Direct biotreatment of the South Tank Farm Plume ensures that benzene levels are significantly and permanently reduced. The mass removal of contaminants reduces the potential for increased loading at the boundary systems. Any remaining contaminants either biodegrade naturally or are removed at the boundary systems. Long-term effectiveness and plume migration are evaluated through continued groundwater monitoring.

8.5.2.4 Reduction of TMV

This alternative reduces the TMV of contaminated groundwater through mass removal of the contaminants with extraction wells at the centers of the plumes. The groundwater intercepted at the South Plants North Source and South Plants Southeast Plumes is treated by a combination of oxidation and GAC adsorption at a rate of 5 gpm. Oxidation decomposes DBCP, benzene, and a major fraction of the VHOs. The residual contaminants (mainly OCPs) in the water are adsorbed onto GAC. Saturated GAC is thermally regenerated off post.

Direct biotreatment of the South Tank Farm Plume groundwater at 5 gpm significantly reduces the toxicity and volume of contaminants, thereby further reducing contaminant migration from the South Tank Farm area. LNAPL is separated and collected for analysis and eventual off-post incineration.

Since the contaminants in the South Plants plumes are removed from the groundwater prior to reinjection, the treatment is irreversible. Some contaminants remain in the South Plants plumes because a fraction of the flow containing contaminants may not be removed by the extraction system, and because some contaminants may remain sorbed to the soil in the aquifer and desorb at a later time.

8.5.2.5 Short-Term Effectiveness

In general, the construction, operation, and final demobilization of this alternative have minimal negative impact on the environment, workers, and the surrounding community. On-post workers are potentially exposed to contaminants through dermal contact and dust inhalation during excavation and water extraction when constructing the recharge trenches. To minimize or prevent such exposure, dust control measures and PPE are used.

The GAC system requires periodic changeout. To reduce potential exposure, personnel are made aware of health and safety procedures and PPE is used.

RAOs are achieved under this alternative. The estimated time for significant reduction of contaminant mass is approximately 10 years (Section 3.2.3).

8.5.2.6 Implementability

This alternative is composed of both well-developed technologies (extraction wells, GAC adsorption, and reinjection trenches) and some innovative technologies (advanced oxidation and direct biological treatment). As discussed in the Technology Description Volume, Sections 5, 11.2, 14.1 and 14.2, most of these technologies are being used successfully at RMA. The

equipment required is commercially available from several vendors. The extraction systems use existing wells supplemented with additional new wells. The water treatment system can be assembled on skids prior to shipment to the site. Startup and training can be performed in an acceptable period of time, and operators at RMA already have experience with most of the components of this system.

The alternative is expected to be reliable. The system allows temporary maintenance to be performed with minimal impacts to the schedule of operation. In many cases, maintenance can be performed without shutting down the system. The biotreatment system requires close oversight and additional training for the operators. Startup of this operation requires more time, but it can be brought online separately from the remainder of the treatment train. The system has automated controls that ensure continued operation with little supervision. The groundwater and the treatment system are adequately monitored during and after extraction/treatment. GAC and hydrogen peroxide are produced and supplied in sufficient quantities by qualified vendors who are responsible for the transportation and regeneration of the spent carbon. The sludge containing inorganics is stabilized and disposed, along with bag filters, in the on-post RCRA landfill.

8.5.2.7 Cost

The capital cost of this treatment system is estimated to be $5,650,000. Approximate annual O&M costs, including monitoring, for years 1 to 5, which include LNAPL treatment, are $826,000. The annual O&M costs for years 6 to 10, including monitoring, are $815,000. The annual O&M costs for the remaining 20 years, including monitoring, are $152,000. The present worth cost of the entire remedial alternative is $13,500,000. A summary of costs is presented in Appendix A, Table A5-5.

8.6 ALTERNATIVE SPC-5/SPT-2/SPT-5: MASS REDUCTION, STRIPPING/SORPTION, IN SITU BIODEGRADATION

This alternative consists of extraction and aboveground treatment of groundwater from the South Plants North Source and South Plants Southeast Plumes, combined with in situ treatment of the South Tank Farm Plume. Extraction is performed using a mass reduction configuration, and LNAPL in the South Tank Farm Plume is removed by a dual-pump system. Extracted water from the South Plants North Source and South Plants Southeast Plumes is treated at the Basin A/South Plants treatment plant using air stripping and GAC adsorption. Treated water is then reinjected into two recharge trenches located in Section 27. Water from the South Tank Farm Plume is treated by in situ biodegradation. The in situ biological treatment of the South Tank Farm Plume is what distinguishes this alternative from Alternative SPC-3. This alternative is accomplished in conjunction with the preferred Basin A groundwater alternative and also with soils remedial activities, which include caps over the Basin A and South Plants areas. Table 8.4–1 presents the estimated chemical influent concentrations for the South Plants North Source and South Plants Southeast Plumes, and Table 8.6-1 presents the estimated chemical influent concentrations for the South Tank Farm Plume in situ biological treatment.

8.6.1 Description of Alternative

8.6.1.1 Extraction/Reinjection

In this alternative, the mass removal, treatment, and reinjection of the South Plants North Source and South Plants Southeast Plumes are the same as described in Alternative SPC-3, as are the well diameters, pumps, and piping. This alternative differs in its use of in situ biodegradation for the South Tank Farm Plume.

The in situ biodegradation system consists of three lines of injection wells and three lines of extraction wells (Figure 8.6-1). The northernmost line of injection wells employs nine wells, the center line eight, and the southernmost line seven. All three lines of extraction wells use five wells to extract the water injected upgradient. The injection wells are 35 ft deep, and the extraction wells are approximately 45 ft deep with 15-ft-long well screens located in the

Weathered Denver Formation. The extracted water is collected in a collection tank prior to nutrient addition and reinjection. The 10 gpm of water is piped back to the injection wells through single-walled piping. The water from the South Plants North Source Plume, South Plants Southeast Plume, and Basin A Plume Group is reinjected in the two reinjection trenches in Section 27 as described in Alternative SPC-3.

8.6.1.2 Treatment

Under this alternative only 2 gpm is extracted from the South Plants North Source and South Plants Southeast Plumes. Due to the low flow rate, it was assumed that this 2-gpm flow is added to the 10 gpm extracted from the Basin A Plume Group. This combined 12-gpm flow is treated by the preferred Basin A Plume Group alternative, which is air stripping followed by GAC adsorption (Alternative AT-2, Section 7.3.1.2). The water from the South Plants North Source and South Plants Southeast Plumes is comparable in quality to the water extracted from the combined plumes in the Basin A Plume Group.

This alternative also includes in situ biodegradation of benzene for the South Tank Farm Plume. Water is extracted from the South Tank Farm Plume at a rate of 10 gpm and an oxygen source and nutrients are mixed into the water prior to reinjection. Figure 8.6-2 displays the flow diagram for this treatment system.

The in situ biodegradation system captures a flow from the South Tank Farm Plume source area. Extracted groundwater is transferred to a collection tank. The extracted water is reinjected after the appropriate amounts of hydrogen peroxide and nutrients have been added; this flushes the plume as it enhances biological growth and degradation of contaminants in the subsurface.

In situ pilot-scale tracer studies and biodegradation studies are required to determine the flow pathways and whether in situ biodremediation can be implemented.

8.6.1.3 Sidestreams

The sidestreams produced in this alternative are limited to the slight increased loading (and therefore increased quantity of sidestreams) at the Basin A water treatment system from the addition of the 2 gpm from South Plants stream (Section 7.3.1.3).

8.6.2 Analysis of Alternative

8.6.2.1 Overall Protection of Human Health and the Environment

Removal of the VHOs, benzene, DBCP, OCPs, and LNAPL from the groundwater in the South Plants North Source and South Plants Southeast Plumes and in situ biodegradation of the benzene in the South Tank Farm Plume results in a reduction in the contaminant mass in the environment. The permanent removal of the contaminants reduces the volume and toxicity of the contaminated groundwater and reduces the migration of the contaminants. A significant mass of contaminants is removed from the centers of the plumes in the first 10 years based on calculations of the quantity of contaminant mass removed. Continued monitoring after 10 years of treatment assesses whether the contaminant concentrations in groundwater have been permanently reduced.

Once extraction and treatment is completed and the extraction systems are discontinued, any remaining contaminants are free to migrate. The contaminants should be at low levels that are expected to be further reduced through natural attenuation, and be intercepted should they migrate to the boundary systems.

8.6.2.2 Compliance with ARARS

This remedial alternative is in compliance with all potential action-specific ARARs listed in the Technology Description Volume, Appendix A, including those related to the extraction systems and air emission controls, because it involves extraction well systems and groundwater treatment systems that comply with these ARARs. Recovery, transportation, and off-post treatment of LNAPL from the South Tank Farm Plume also comply with these potential ARARs. The treatment systems also comply with all potential chemical-specific ARARs listed in Appendix A, Volume I of the Water DSA, and with the FFA. PRGs are achieved at the RMA boundary

through continued operation of the boundary systems. Operation of the extraction well systems and continued operation of the boundary systems, along with appropriate siting of the common groundwater treatment facility, ensure compliance with all potential location-specific ARARs applicable to groundwater, which are listed in Appendix A, Volume I of the Water DSA.

8.6.2.3 Long-Term Effectiveness and Permanence

This alternative reduces the potential for off-post exposure by removing and treating contaminants at the source. In situ biotreatment of the South Tank Farm Plume ensures that benzene levels throughout the aquifer are significantly and permanently reduced. The mass removal of contaminants reduces the potential for increased loading at the boundary systems. Remaining contaminants that are not removed through natural attenuation are treated if they reach the boundary systems. Long-term effectiveness and plume migration are evaluated through continued groundwater monitoring.

8.6.2.4 Reduction of TMV

This alternative reduces the TMV of contaminated groundwater by mass removal of the contaminants with extraction wells at the centers of the plumes. The groundwater intercepted at the South Plants North Source and South Plants Southeast Plumes is combined with water extracted from the Basin A Plume Group and treated by a combination of air stripping and GAC adsorption at the rate of 2 gpm. Air stripping transfers volatile organics from the liquid phase to the vapor phase where they are subsequently destroyed by catalytic oxidation. Residual contaminants (OCPs, DBCP, and volatile organics) in the water are adsorbed onto GAC. Saturated GAC requires off-post thermal regeneration.

In situ biotreatment, involving recirculation of 10 gpm of water from the South Tank Farm Plume, significantly reduces the toxicity and volume of contaminants, thereby further reducing contaminant migration from the South Tank Farm area. LNAPL is separated and collected for analysis and eventual off-post incineration.

Since the contaminants in the South Plants North Source and South Plants Southeast Plumes are removed from the groundwater prior to reinjection, the treatment is irreversible. A large fraction of the contaminants in the South Tank Farm Plume are destroyed by in situ biodegradation. Some contaminants remain in the South Plants plumes because a fraction of the flow containing contaminants may not be removed by the extraction system, because a fraction of the contaminants may not biodegrade, and because some contaminants may remain sorbed to the soil in the aquifer and desorb at a later time.

8.6.2.5 Short-Term Effectiveness

In general, the construction, operation, and final demobilization of this alternative have minimal negative impact on the environment, workers, and the surrounding community. On-post workers are potentially exposed to contaminants through dermal contact and dust inhalation during excavation and water extraction when constructing the recharge trenches. To minimize or prevent such exposure, dust control measures and PPE are used.

In situ biotreatment has minimal negative impact on the environment, workers, and the surrounding community since treatment is carried out in the subsurface environment. Operation of the system involves some chemical handling that requires the use of PPE.

RAOs are achieved under this alternative. The estimated time frame for significant reduction of contaminant mass is approximately 10 years based on the average volumetric estimates.

8.6.2.6 Implementability

With the exception of in situ biological treatment, this alternative is composed of well-developed technologies: extraction wells, air stripping, GAC adsorption, catalytic oxidation, and reinjection trenches. As discussed in Sections 5, 14.2, 14.3, and 15 of the Technology Description Volume, these technologies are all being used successfully at RMA. The equipment required is commercially available from several vendors. The extraction systems use existing wells supplemented with additional new wells. The water treatment system from the selected Basin

A remedial alternative is capable of handling the 2-gpm flow from the South Plants North Source and South Plants Southeast Plumes. The groundwater from these plumes is similar in quality to the groundwater from the Basin A plumes; it can therefore be mixed without upsetting the Basin A treatment system.

The alternative is expected to be reliable. In situ pilot-scale tracer and biodegradation studies are required to determine whether in situ biodegradation can be implemented. The in situ treatment system requires simple equipment that is easily installed. Operation is primarily associated with monitoring and feed adjustments. The system can operate continuously throughout the year. The groundwater and the treatment system are adequately monitored during and after extraction/treatment.

8.6.2.7 Cost

The capital cost of this treatment system is estimated to be $4,280,000. Approximate annual O&M costs, including monitoring, for years 1 to 5, which includes LNAPL treatment, are $538,000. The annual O&M costs for years 6 to 10, including monitoring, are $526,000. The annual O&M costs, including monitoring, for years 11 to 30 are $244,000. The present worth cost of the entire remedial alternative is $10,500,000. A summary of costs is presented in Appendix A, Table A5-6.

8.7 ALTERNATIVE SPC-6/SPT-2/SPT-5: MASS REDUCTION/DEWATERING, STRIPPING/SORPTION, IN SITU BIODEGRADATION

This alternative consists of groundwater extraction from the South Plants North Source, South Plants Southeast, and South Tank Farm Plumes. Extraction is completed in a mass reduction configuration for the South Plants North Source and South Plants Southeast Plumes; LNAPL in the South Tank Farm Plume is separated using a dual-pump system. Groundwater in the South Tank Farm Plume is treated by in situ biodegradation. A dewatering grid is added after soils and structures media remedial activities are completed. The phased approach of mass reduction and dewatering distinguishes this control alternative from the previous control alternatives. Extracted

water is treated at the Basin A/South Plants combined treatment plant using air stripping and GAC adsorption and is then reinjected into two recharge trenches located in Section 27. This alternative is accomplished in conjunction with the preferred Basin A groundwater alternative and with soils remedial activities. Tables 8.4-1 and 8.6-1 present the estimated chemical influent concentrations for the first phase of this alternative. The concentrations are the same as those in Alternative SPC-5/SPT-2/SPT-5 (Section 8.6). Table 8.7-1 presents the estimated chemical influent concentrations for the dewatering phase.

8.7.1 Description of Alternative

8.7.1.1 Extraction/Reinjection

This alternative consists of a phased approach beginning with mass reduction (as described in Alternative SPC-5) followed by groundwater mound dewatering (as described in this alternative). The South Tank Farm Plume is treated in situ. As in all South Plants alternatives, the LNAPL extraction well located in the South Tank Farm Plume operates for approximately 5 years. Once the mass reduction phase is complete, most of the mass of contamination has been removed and the mound dewatering grid ensures hydraulic gradient control, which prevents a rise in the water table and future migration of contaminants.

Figures 8.7-1 and 8.7-2 present a schematic of the phased approach used in this alternative. For the first 10 years, the mass reduction system described in Alternative SPC-5/SPT-2/SPT-5 (Section 8.6) is used, treating a total of 12 gpm. The mass reduction systems, which are generally outside the areas of major soils and structures remediation, are small and employ few wells. Therefore, the systems should not be damaged by, or inhibit soils and structures remedial activities in the South Plants area. The South Plants North Source extraction system is in the area of major soils and structures remedial activities, but since it only uses five wells it should not significantly inhibit soil and structures remediation operations.

When soils and structures remedial activities are completed in the South Plants area, wells will be constructed to form a dewatering grid that uses 48 extraction wells and pumps a total of 30

gpm. The wells used for mass reduction of the South Plants North Source and South Plants Southeast Plumes are to be incorporated into the dewatering grid. The wells installed for the dewatering grid are approximately 42 ft deep, with 15-ft-long well screens completed in the weathered Denver Formation. Well construction, pump sizing, and piping are the same as for Alternative SPC-3/SPT-2. Submersible pumps are installed in each well and are connected to a collector manifold. The water is piped to a collection tank in the vicinity of the extraction wells and pumped from the collection tank to the proposed Basin A/South Plants combined treatment plant. Four collection tanks and booster pumps are used for the dewatering system, one in each quadrant of the extraction field. The groundwater extracted from dewatering the South Plants groundwater mound is treated separately or combined with Basin A Plume Group groundwater, if groundwater continues to be extracted from this plume group. The treated groundwater from the South Plants dewatering grid (30 gpm) is piped to two injection trenches using single-walled Schedule 40 PVC piping. The trenches are of the same design and in the same location as described in Alternative SPC-3.

Groundwater-quality and water-level data from a monitoring network of existing plume evaluation monitoring wells and newly installed performance monitoring wells are used to evaluate the effectiveness and operation of the extraction system. The final location of the new wells is based upon review of existing well locations and screened intervals.

8.7.1.2 Treatment

The extracted groundwater is treated using two different approaches. During the first (mass reduction) phase, the groundwater is treated by a combination of in situ biodegradation of the South Tank Farm Plume and treatment of the South Plants North Source and South Plants Southeast Plumes by the Basin A treatment system (Section 7.3.1.2). Any LNAPL removed from the plumes is drummed for eventual off-post incineration. The description of this treatment scenario is identical to that given for Alternative SPC-5/SPT-2/SPT-5 in Section 8.6.1.2. This treatment continues for 10 years based on volumetric estimates of water removal needed to significantly reduce the contaminant mass in groundwater in the plume center.

In year 10, a treatment system is assembled in South Plants to treat the water extracted in the second phase, the dewatering phase, which commences in year 11. This treatment system uses air stripping followed by GAC to remove contamination from the groundwater at a rate of 30 gpm. The stripping/sorption system used in this alternative is described in detail in Section 8.2.1.2. Due to the 30-gpm flow rate of this alternative, the air stripper is 27 ft high and has an air/water ratio of 50. The GAC required by the increased flow is 9,200 lbs per year. All tanks and pumps are also designed for a 30-gpm flow rate. Figure 8.2-1 presents a process flow diagram showing the major pieces of treatment equipment as well as tanks, pumps, and filters used in this alternative.

8.7.1.3 Sidestreams

In addition to the sidestreams generated by the first phase (as discussed in Section 8.6.1.3), this treatment system produces two major sidestreams, vapor emissions from the air stripper and spent carbon. In addition, smaller streams such as the acid wash from the air stripper and used bags from the filters are also generated.

The vapor-phase emissions from the air stripper are treated with catalytic oxidation. Because this process actually breaks down the contaminants instead of transferring them to another medium, no further treatment of the vapor-phase emissions is required.

The acid wash for the air stripper packing is neutralized in the wastewater tank. It is also anticipated that the packing must be replaced once a year. If the packing can be decontaminated, it is sent to a sanitary landfill; if not, it is sent to the on-post hazardous waste landfill as described in the Technology Description Volume, Section 6.5. The spent carbon from the GAC units is collected by the vendor supplying the carbon and is thermally regenerated off post.

Used bags from filters are drummed and transported to the on-post hazardous waste landfill because they have been in contact with hazardous materials. The wastewater from the

wastewater tank is sent to the CERCLA Wastewater Treatment Plant and the sediments from the wastewater tank are drummed and landfilled.

8.7.2 Analysis of Alternative

8.7.2.1 Overall Protection of Human Health and the Environment

Removal of VHOs, benzene, DBCP, OCPs, and LNAPL from the groundwater in the South Plants North and South Plants Southeast Plumes and biodegradation of the benzene in the South Tank Farm Plume results in a reduction in the contaminant mass in the environment. Extended dewatering of the South Plants groundwater mound results in further removal of the chloroform, benzene, and DBCP. The permanent removal of the contaminants reduces the volume and toxicity of the contaminated groundwater and reduces the migration of the contaminants. A significant mass of contaminants is removed from the centers of the plumes in the first 10 years based on volumetric estimates of the central portion of the plumes. Continued monitoring after the demobilization of the mass removal system assesses whether 10 years of mass removal has permanently reduced the toxicity of the groundwater. A dewatering grid further removes remaining contamination and reduces the groundwater mound, hence controlling groundwater flow. The possibility for contaminant migration, including flow of contaminants into new pathways resulting from different hydraulic conditions, is reduced. The amount of contaminated soil in contact with the groundwater is also reduced by lowering the water table.

8.7.2.2 Compliance with ARARS

This remedial alternative is in compliance with all potential action-specific ARARs listed in the Technology Description Volume, Appendix A, including those related to the extraction systems and air emission controls, because it involves extraction well systems and groundwater treatment systems that comply with these ARARs. Recovery, transportation, and off-post treatment of LNAPL from the South Tank Farm Plume also comply with potential ARARs. The treatment systems also comply with all potential chemical-specific ARARs listed in Appendix A, Volume I of the Water DSA, and with the FFA. PRGs are achieved at the RMA boundary through continued operation of the boundary systems. Operation of the extraction well systems and

continued operation of the boundary systems, along with appropriate siting of the Basin A/South Plants treatment plant, ensures compliance with all potential location-specific ARARs applicable to groundwater, which are listed in Appendix A, Volume I of the Water DSA, and with the FFA.

8.7.2.3 Long-Term Effectiveness and Permanence

This alternative reduces the potential for off-post exposure by removing and treating contaminants at the source. In situ biotreatment of the South Tank Farm Plume ensures that benzene levels throughout the aquifer are significantly and permanently reduced. The mass removal of contaminants reduces the potential for increased loading at the boundary systems. The dewatering system controls the flow of contaminants from the mound in all directions. Treatment and reinjection of extracted groundwater from dewatering continues. Natural attenuation also reduces contaminant levels in the aquifer. Long-term effectiveness and plume migration are evaluated through continued groundwater monitoring.

8.7.2.4 Reduction of TMV

This alternative reduces TMV of contaminated groundwater by mass removal of the contaminants with extraction wells at the centers of the plumes. The groundwater intercepted at the South Plants North Source and South Plants Southeast Plumes is treated by a combination of air stripping and GAC adsorption at a rate of 2 gpm. Air stripping transfers volatile organics from the liquid phase to the vapor phase where they are subsequently destroyed by catalytic oxidation. Residual contaminants in the water are adsorbed onto GAC. Saturated GAC requires off-post thermal regeneration.

In situ biodegradation, involving recirculation of 10 gpm of water from the South Tank Farm Plume, significantly reduces the toxicity and volume of contaminants, thereby further reducing contaminant migration from the South Tank Farm area. LNAPL is separated and collected for analysis and eventual off-post incineration.

After mass reduction is complete, remaining contamination is further immobilized by the reduction of the South Plants groundwater mound. The water table is lowered, thus reducing the amount of contaminated soil in contact with the groundwater. Migration of contaminants is reduced by the lowering of hydraulic heads. Most of the remaining contamination is collected by the dewatering system and treated.

The groundwater extracted from the South Plants dewatering wells is treated by a combination of air stripping and GAC adsorption at a rate of 30 gpm. Air stripping transfers volatile organics from the liquid phase to the vapor phase where they are subsequently destroyed by catalytic oxidation. Residual contaminants (OCPs, DBCP, and volatile organics) in the water are adsorbed onto GAC. Saturated GAC requires off-post thermal regeneration.

Since the contaminants in the South Plants plumes are removed from the groundwater prior to reinjection, the treatment is irreversible. A large fraction of the contaminants in the South Tank Farm Plume are destroyed by in situ biodegradation. Some contaminants remain in the South Plants plumes because a fraction of the flow containing contaminants may not be removed by the extraction system, because a fraction of the contaminants may not biodegrade, and because some contaminants may remain sorbed to the soil in the aquifer and desorb at a later time.

8.7.2.5 Short-Term Effectiveness

In general, the construction, operation, and final demobilization of this alternative have minimal negative impact on the environment, workers, and the surrounding community. On-post workers are potentially exposed to contaminants through dermal contact and dust inhalation during excavation when constructing the recharge trenches. To minimize or prevent such exposure, dust control measures and PPE are used. The GAC system requires periodic changeout of spent carbon. To reduce potential exposure, personnel are made aware of health and safety procedures and PPE is used.

In situ biotreatment has minimal negative impact on the environment, workers, and the surrounding community since treatment is carried out in the subsurface environment. Operation of the system involves some chemical handling that requires PPE.

RAOs are achieved under this alternative. The system may have to operate for more than 100 years.

8.7.2.6 Implementability

With the exception of in situ biological treatment, this alternative is composed of well-developed technologies: extraction wells, air stripping, GAC adsorption, catalytic oxidation, and reinjection trenches. As discussed in Sections 5, 14.2, 14.3, and 15 of the Technology Description Volume, most of these technologies are being used successfully at RMA. The equipment required is commercially available from several vendors. Extraction systems, transport systems, and reinjection systems are implementable, time-proven technologies that are also currently in use at RMA. The water treatment system from the preferred Basin A remedial alternative is capable of handling the 2-gpm flow from the South Plants North Source and South Plants Southeast Plumes during the mass reduction phase. The groundwater from these plumes is similar in quality to that from the Basin A plumes and therefore can be mixed without upsetting the preferred Basin A alternative treatment system (Section 7.3.1.2).

The water treatment system required for treating groundwater in the South Plants plumes during the dewatering phase can be assembled on skids prior to shipment to the site. Startup and training can be performed in an acceptable period of time, and operators at RMA already have experience with most of the components of this system.

The alternative is expected to be reliable. In situ pilot-scale tracer and biodegradation studies are required to determine whether in situ biodegradation can be implemented. The in situ treatment system requires simple equipment that is easily installed. Operation is primarily associated with monitoring and feed adjustments. All systems allow temporary maintenance to

be performed with minimal impacts to the schedule of operation. In many cases, maintenance can be performed without shutting down the system. The systems have automated controls that ensure continued operation with little supervision. The groundwater and the treatment system are adequately monitored during and after extraction/treatment.

GAC and air stripper packing are produced and supplied in sufficient quantities by qualified vendors. GAC vendors are responsible for the transportation of GAC. The sludge containing inorganics is stabilized and disposed, along with bag filters, in the on-post landfill. Precious metals are removed from spent catalyst by the supply vendor.

8.7.2.7 Cost

The capital cost of this treatment system (including both phases of operation) is estimated to be $6,100,000. Approximate annual O&M costs for years 1 to 5, which include LNAPL treatment and monitoring, are $550,000. The annual O&M costs for years 6 to 10, including monitoring, are $539,000. The annual O&M costs for years 11 to 30, including monitoring, are $864,000. The present worth cost for 30 years of extraction/treatment is $17,400,000. A summary of costs is presented in greater detail in Appendix A, Table A5-7.

8.8 ALTERNATIVE SPC-6/SPT-3/SPT-5: MASS REDUCTION/DEWATERING, OXIDATION/SORPTION, IN SITU BIODEGRADATION

This alternative consists of groundwater extraction from the South Plants North Source, South Plants Southeast, and South Tank Farm Plumes. During the first 10 years, extraction is completed in a mass reduction configuration for the South Plants North Source and South Plants Southeast Plumes. LNAPL in the South Tank Farm Plume is removed by a dual-pump system. The South Tank Farm Plume is treated by in situ biodegradation. A dewatering grid is added after soils and structures media remedial activities are completed. Water extracted during the dewatering phase (years 11 to 30) is treated with oxidation and GAC adsorption (which differentiates this alternative from Alternative SPC-6/SPT-2/SPT-5) and is then reinjected into two recharge trenches in Section 27. Tables 8.4-1 and 8.6-1 list the estimated chemical influent

concentrations for the first phase (mass reduction) of this alternative. The chemical concentrations are the same as those in Alternative SPC-5/SPT-2/SPT-5 (Section 8.6). Table 8.7-1 lists the estimated chemical influent concentrations for the second (dewatering) phase.

8.8.1 Description of Alternative

8.8.1.1 Extraction/Reinjection

This alternative includes the same groundwater control systems that are used for Alternative SPC-6/SPT-2/SPT-5 (Sections 8.6.1.1 and 8.7.1.1).

8.8.1.2 Treatment

The extracted groundwater is treated using a phased approach. During the first phase (mass reduction), the groundwater is treated by a combination of in situ biodegradation of the South Tank Farm Plume and treatment of the South Plants North Source and South Plants Southeast Plumes by the preferred Basin A treatment system (Section 7.3.1.2). Any LNAPL removed from the plumes is drummed for eventual off-post incineration. This treatment scenario is identical to that for Alternative SPC-5/SPT-2/SPT-5 (Section 8.6.2). This treatment continues for 10 years based on volumetric estimates of water removal needed to significantly reduce the contaminant mass in the groundwater in the centers of the plumes.

In year 10, a treatment system is assembled in South Plants to treat the water extracted in the second phase (dewatering), which commences in year 11. This treatment system uses oxidation followed by GAC to remove contamination from the groundwater at a rate of 30 gpm. Figure 8.8-1 is a process flow diagram showing the major pieces of treatment equipment as well as tanks, pumps, and filters used in this alternative.

Extracted water is stored in a collection tank prior to being treated. From there the water is pumped first to the oxidation reactor and then to the GAC adsorbers, as described in Section 8.3.1.2. All equipment is sized for a 30-gpm flow and vapor emissions from the oxidation reactor are treated with vapor-phase GAC adsorption.

8.8.1.3 Sidestreams

In addition to the sidestreams generated by the first phase (as described in Section 8.6.1.3), the primary sidestreams produced by this treatment system are vapor emissions from the oxidation reactor, spent carbon, and used bags from the filters.

Vapor-phase emissions from the oxidation reactor consist primarily of organics that volatilize from the water. These are adsorbed onto vapor-phase GAC, which requires regeneration. Spent carbon from the liquid- and vapor-phase GAC units is collected by the vendor supplying the carbon and is thermally regenerated off post.

Used bags from filters are drummed and sent to the on-post landfill as described in the Technology Description Volume, Section 6.5. The wastewater in the wastewater tank is sent to the CERCLA Wastewater Treatment Plant and the sediments from the wastewater tank are drummed and landfilled.

8.8.2 Analysis of Alternative

8.8.2.1 Overall Protection of Human Health and the Environment

Removal of VHOs, benzene, DBCP, OCPs, and LNAPL from the groundwater in the South Plants North Source and South Plants Southeast Plumes and biodegradation of the benzene in the South Tank Farm Plume results in a reduction in the contaminant mass in the environment. Extended dewatering of the South Plants plumes results in further removal of chloroform, benzene, and DBCP.

The permanent removal of the contaminants reduces the volume and toxicity of the contaminated groundwater and reduces the migration of the contaminants. A significant mass of contaminants is removed from the centers of the plumes in the first 10 years based on estimates of the volume of highly contaminated groundwater in the central portion of the plumes. A dewatering grid further removes the remaining contamination and reduces the groundwater mound, hence controlling groundwater flow. The amount of contaminated soil in contact with the groundwater

is also reduced by lowering the water table. The dewatering system continues to operate indefinitely, thereby controlling hydraulic conditions and treating the remaining contamination.

8.8.2.2 Compliance with ARARS

This remedial alternative is in compliance with all potential action-specific ARARs listed in the Technology Description Volume, Appendix A, including those related to the extraction systems and air emission controls, because it involves extraction well systems and groundwater treatment systems that comply with these ARARs. Recovery, transportation, and off-post treatment of LNAPL from the South Tank Farm Plume also comply with these potential ARARs. The treatment systems also comply with all potential chemical-specific ARARs listed in Appendix A, Volume I of the Water DSA, and with the FFA. PRGs are achieved at the RMA boundary through continued operation of the boundary systems. Operation of the extraction well systems and continued operation of the boundary systems, along with appropriate siting of the common groundwater treatment facility, ensure compliance with all potential location-specific ARARs applicable to groundwater, which are listed in Appendix A, Volume I of the Water DSA, and with the FFA.

8.8.2.3 Long-Term Effectiveness and Permanence

This alternative reduces the potential for off-post exposure by removing and treating contaminants at the source. In situ biotreatment of the South Tank Farm Plume ensures that benzene levels throughout the aquifer are significantly and permanently reduced. The mass removal of contaminants reduces the potential for increased loading at the boundary systems. The dewatering system controls the flow of contaminants and minimizes migration to the west and northwest, the primary directions of flow. Treatment and reinjection of the extracted groundwater from the dewatering continues. The contaminants are suspended in the vadose zone when dewatering is complete. Long-term effectiveness and plume migration are evaluated through continued groundwater monitoring.

8.8.2.4 Reduction of TMV

This alternative reduces the TMV of contaminated groundwater by mass removal of the contaminants with extraction wells at the centers of the plumes. The groundwater intercepted at the South Plants North Source and South Plants Southeast Plumes is treated by a combination of air stripping and GAC adsorption at a rate of 2 gpm. Ozone in the oxidation reactor causes some volatilization of organics from the water phase. Vapor emissions are subsequently transferred to vapor-phase GAC. Residual contaminants (OCPs and DBCP) in the water are adsorbed onto GAC. Saturated liquid and vapor-phase GAC require off-post thermal regeneration.

In situ biotreatment, involving recirculation of 10 gpm of water from the South Tank Farm Plume, significantly reduces the toxicity and volume of contaminants, thereby further reducing contaminant migration from the South Tank Farm area. Any LNAPL encountered is separated during pumping and collected for analysis and eventual off-post incineration.

After the mass reduction phase, the remaining contamination is further immobilized by the reduction of the South Plants groundwater mound. The water table is lowered due to both decreased man-made recharge and to dewatering, thereby reducing the amount of contaminated soil in contact with the groundwater. The migration of the contaminants is reduced by the lower hydraulic heads and much of the remaining contamination is collected by the dewatering system and treated.

The groundwater extracted from the South Plants dewatering wells is treated by a combination of oxidation and GAC adsorption at a rate of 30 gpm. Oxidation decomposes DBCP, benzene, and a major fraction of the VHOs. The residual contaminants (mainly OCPs) in the water are adsorbed onto GAC. Saturated GAC requires off-post thermal regeneration. Any VHOs stripped in the oxidation reactor and emitted in the ozone off gas are removed by vapor-phase GAC adsorption.

Since the contaminants in the South Plants plumes are removed from the groundwater prior to reinjection, the treatment is irreversible. A large fraction of the contaminants in the South Tank Farm Plume are destroyed by in situ biodegradation. Some contaminants remain in the South Plants plumes because a fraction of the flow containing contaminants may not be removed by the extraction system, because a fraction of the contaminants may not biodegrade, and because some contaminants may remain sorbed to the soil in the aquifer and desorb at a later time.

8.8.2.5 Short-Term Effectiveness

In general, the construction, operation, and final demobilization of this alternative have minimal negative impact on the environment, workers, and the surrounding community. On-post workers are potentially exposed to contaminants through dermal contact and dust inhalation during excavation when constructing the recharge trenches. To minimize or prevent such exposure, dust control measures and PPE are used. Personnel must follow specified procedures when repairing or operating the ozone generator or when changing out the carbon. To reduce potential exposure, personnel are made aware of health and safety procedures and PPE is used.

In situ biotreatment has minimal negative impact on the environment, workers, and the surrounding community since treatment is carried out in the subsurface environment. Operation of the system involves some chemical handling that requires PPE.

RAOs are achieved under this alternative over an extended period of time. This remedial action may have to be operated for more than 100 years.

8.8.2.6 Implementability

This alternative is composed of both well-developed technologies (extraction wells, air stripping, GAC adsorption, and reinjection trenches) and innovative technologies (in situ biological treatment, catalytic oxidation, and ozone/hydrogen peroxide oxidation). As discussed in Sections 5, 11.3, 14.1, 14.2, 14.3 and 15, of the Technology Description Volume, most of these technologies are being used successfully at RMA. The equipment required is commercially

available from several vendors, with the exception of oxidation, for which a limited number of vendors supply the equipment. Extraction systems, transport systems, and reinjection systems are implementable, time-proven technologies currently in use at RMA. The water treatment system from the preferred Basin A treatment alternative is capable of handling the 2-gpm flow from the South Plants North Source and South Plants Southeast Plumes during the mass reduction phase. The groundwater from these plumes is similar in quality to the groundwater from the Basin A plumes and can therefore be mixed without upsetting the preferred Basin A treatment system (Section 7.3.1.2).

The water treatment system required for treating the South Plants groundwater during the dewatering phase can be assembled on skids prior to shipment to the site. Startup and training can be performed in an acceptable period of time. Operators at RMA already have experience with most of the components of this system.

The alternative is expected to be reliable. In situ pilot-scale tracer and biodegradation studies are required to determine whether in situ biodegradation can be implemented. The in situ treatment system requires simple equipment that is easily installed. Operation is primarily associated with monitoring and feed adjustments. All systems allow temporary maintenance to be performed with minimal impacts to the schedule of operation. In many cases, maintenance can be performed without shutting down the system. The systems have automated controls that ensure continued operation with little supervision. The groundwater and the treatment system are adequately monitored during and after extraction/treatment.

GAC and hydrogen peroxide are produced and supplied in sufficient quantities by qualified vendors. GAC vendors are responsible for the transportation of GAC. The sludge containing inorganics is stabilized and disposed, along with bag filters, in the on-post landfill.

8.8.2.7 Cost

The capital cost of this treatment system (including both phases of operation) is estimated to be $7,680,000. Approximate annual O&M costs, including monitoring for years 1 to 5, which includes LNAPL treatment, are $550,000. The annual O&M costs for years 6 to 10, including monitoring, are $539,000. The annual O&M costs for years 11 to 30, including monitoring, are $874,000. The present worth cost for 30 years of remediation is $19,100,000. A summary of cost is presented in Appendix A, Table A5-8.

8.9 ALTERNATIVE SPC-7/SPT-2/SPT-5: MASS REDUCTION/DEWATERING/CAP, STRIPPING/SORPTION, IN SITU BIODEGRADATION

This alternative consists of groundwater extraction from the South Plants North Source, South Plants Southeast, and South Tank Farm Plumes. Extraction is completed in a mass reduction configuration. LNAPL in the South Tank Farm Plume is removed by a dual-pump system. The South Tank Farm Plume is treated by in situ bioremediation. A dewatering grid and cap are added after soils and structures remedial activities are completed. The addition of a cap, which reduces recharge, is what distinguishes this alternative from Alternative SPC-6. Extracted water is treated at the Basin A/South Plants treatment plant using air stripping and GAC adsorption and is then reinjected into two recharge trenches located in Section 27. This alternative is accomplished in conjunction with the preferred Basin A groundwater alternative (Section 7.3.1.2) and with soils remedial activities, which include caps over the Basin A and South Plants areas. Tables 8.4-1 and 8.6-1 list the estimated chemical influent concentrations for the first phase (mass reduction) of this alternative. The concentrations are the same as those in Alternative SPC-5/SPT-2/SPT-5 (Section 8.6). Table 8.9-1 lists the estimated chemical influent concentrations for the second phase (dewatering) with a cap in place.

8.9.1 Description of Alternative

8.9.1.1 Extraction/Reinjection

Alternative SPC-7 is identical to Alternative SPC-6 except that a cap is added to the South Plants Central Processing Area as part of the soils medium remediation. The flow rates for the mass

reduction system under the first phase (mass reduction), are the same. The flow rate for the second phase (dewatering) is decreased by 5 gpm to a total flow rate of 25 gpm.

8.9.1.2 Treatment

The extracted groundwater is treated using two methods in this phased approach. During the first phase, the groundwater is treated by a combination of in situ biodegradation of the South Tank Farm Plume and treatment of the South Plants North Source and South Plants Southeast Plumes by the preferred Basin A treatment alternative. Any LNAPL removed is drummed for eventual off-post incineration. The description of this treatment scenario is identical to that given for Alternative SPC-5/SPT-2/SPT-5 in Section 8.6.1.2. This treatment continues for approximately 10 years based on volumetric estimates of water removal needed to significantly reduce the contaminant mass in groundwater in the centers of the plumes.

In year 10, a treatment system is assembled in South Plants to treat the water extracted in the second phase (dewatering), which commences in year 11. The system uses air stripping followed by GAC adsorption to treat the extracted groundwater, which is identical to the treatment system described for Alternative SPC-6/SPT-2/SPT-5 (Section 8.7.1.2).

8.9.1.3 Sidestreams

The sidestreams generated in the first phase of this alternative are the same as those described for Alternative SPC-5/SPT-2/SPT-5 (Section 8.6.1.3). The second phase of this alternative generates sidestreams identical to those described for Alternative SPC-6/SPT-2/SPT-5 (Section 8.7.1.2).

8.9.2 Analysis of Alternative

8.9.2.1 Overall Protection of Human Health and the Environment

Removal of VHOs, benzene, DBCP, OCPs, and LNAPL from the groundwater in the South Plants North Source and South Plants Southeast Plumes and biodegradation of the benzene in the South Tank Farm Plume results in a reduction in the contaminant mass in the environment.

Extended dewatering of the South Plants plumes results in further removal of chloroform, benzene, and DBCP.

The permanent removal of the contaminants reduces the volume and toxicity of the contaminated groundwater and reduces the migration of the contaminants. A significant mass of contaminants is removed from the centers of the plumes in the first 10 years based on estimates of the volume of highly contaminated groundwater found in the central portions of the plumes. Continued monitoring after the demobilization of the mass removal system assesses whether 10 years of mass removal has permanently reduced the toxicity of the groundwater. A dewatering grid further removes remaining contamination and reduces the groundwater mound, hence controlling groundwater flow. The possibility for contaminant migration through new pathways is reduced as a result of the changed hydraulic conditions. The amount of contaminated soil in contact with the groundwater is also reduced by lowering the water table. The leaching of contaminants from the South Plants Central Processing Area is reduced by the installation of a cap, thus suspending contaminants in the vadose zone once dewatering is complete.

8.9.2.2 Compliance with ARARS

This remedial alternative is in compliance with all potential action-specific ARARs listed in the Technology Description Volume, Appendix A, including those related to the extraction systems and air emission controls, because it involves extraction well systems and groundwater systems that comply with these ARARs. Recovery, transportation, and off-site treatment of LNAPL from the South Tank Farm Plume also comply with these potential ARARs. The treatment systems also comply with all potential chemical-specific ARARs listed in Appendix A of the Water DSA, and with the FFA. PRGs are achieved at the RMA boundary through continued operation of the boundary systems. Operation of the extraction well systems and continued operation of the boundary systems, along with appropriate siting of the common groundwater treatment facility, ensure compliance with all potential location-specific ARARs applicable to groundwater, which are listed in Appendix A, Volume I of the Water DSA, and with the FFA.

8.9.2.3 Long-Term Effectiveness and Permanence

This alternative reduces the potential for off-post exposure by removing and treating contaminants at the source. In situ biotreatment of the South Tank Farm Plume ensures that benzene levels throughout the aquifer are significantly and permanently reduced. The mass removal of contaminants reduces the potential for increased loading at the boundary systems. The dewatering system controls the flow of contaminants to the west and northwest, the primary directions of flow. Treatment and reinjection of extracted groundwater from dewatering continues. Contaminants are suspended in the soil column when dewatering is complete and the water table is lowered. The cap reduces the leaching of those contaminants suspended in the vadose zone and natural attenuation reduces contaminant levels in the aquifer. Long-term effectiveness and plume migration are evaluated through continued groundwater monitoring.

8.9.2.4 Reduction of TMV

This alternative reduces the TMV of contaminated groundwater by mass removal of the contaminants with extraction wells at the centers of the plumes. The groundwater intercepted at the South Plants North Source and South Plants Southeast Plumes is treated by a combination of air stripping and GAC adsorption at a rate of 2 gpm. Air stripping transfers volatile organics from the liquid phase to the vapor phase where they are subsequently destroyed by catalytic oxidation. Residual contaminants (OCPs, DBCP, and volatiles) in the water are adsorbed onto GAC. Saturated GAC requires off-post thermal regeneration.

In situ biotreatment, involving recirculation of 10 gpm of water from the South Tank Farm Plume, significantly reduces the toxicity and volume of contaminants, thereby further reducing contaminant migration from the South Tank Farm area. Any LNAPL encountered is separated during pumping and collected for eventual off-post incineration.

After the mass reduction phase is complete, remaining contamination is further immobilized by the lowering of the South Plants groundwater mound. The water table is lowered due to both decreased man-made recharge and to dewatering, thereby reducing the amount of contaminated

soil in contact with the groundwater. The cap reduces the leaching of the contaminants suspended in the soil column under the South Plants Central Processing Area. Migration of contaminants is reduced when the hydraulic heads are lowered. Most of the remaining contamination is collected by the dewatering system and treated.

The groundwater extracted from the South Plants dewatering wells is treated by a combination of air stripping and GAC adsorption at a rate of 25 gpm. Air stripping transfers volatile organics from the liquid phase to the vapor phase where they are subsequently destroyed by catalytic oxidation. Residual contaminants (OCPs, VHOs, and DBCP) in the water are adsorbed onto GAC. Saturated GAC requires off-post thermal regeneration.

Since the contaminants in the South Plants plumes are removed from the groundwater prior to reinjection, the treatment is irreversible. A large fraction of the contaminants in the South Tank Farm Plume are destroyed by in situ biodegradation. There will be some contaminants that may remain in the South Plants plumes because a fraction of the flow containing contaminants may not be removed by the extraction system, because a fraction of the contaminants may not biodegrade, and because some contaminants may remain sorbed to the soil in the aquifer and desorb at a later time.

8.9.2.5 Short-Term Effectiveness

In general, the construction, operation, and final demobilization of this alternative have minimal negative impact on the environment, workers, and the surrounding community. On-post workers would potentially be exposed to contaminants through dermal contact and dust inhalation during excavation when constructing the recharge trenches. To minimize or prevent such exposure, dust control measures and PPE are used. The GAC system requires periodic changeout of GAC. To reduce the potential for exposure, personnel are made aware of health and safety procedures and PPE is used.

In situ biotreatment has minimal negative impact on the environment, workers, and the surrounding community since treatment is carried out in the subsurface environment. Operation of the system involves some chemical handling that requires PPE.

RAOs are achieved under this alternative. This remedial action may have to be operated for more than 100 years.

8.9.2.6 Implementability

With the exception of in situ biological treatment, this alternative is composed of well-developed technologies: extraction wells, air stripping, GAC adsorption, catalytic oxidation, and reinjection trenches. As discussed in Sections 5, 11.3, 14.2, 14.3, and 15 of the Technology Description Volume, most of these technologies are being used successfully at RMA. The equipment required is commercially available from several vendors. Extraction systems, transport systems, and reinjection systems are implementable, time-proven technologies similar to those that are currently in use at RMA. The water treatment system from the preferred Basin A remedial alternative is capable of handling the 2-gpm flow from the South Plants North and South Plants Southeast Plumes during the mass reduction phase. The groundwater from these plumes is similar in quality to the groundwater from the Basin A plumes and can therefore be mixed without upsetting the treatment system for the preferred Basin A alternative (Section 7.3.1.2).

The water treatment system required for treating the South Plants groundwater during the dewatering phase can be assembled on skids prior to shipment to the site. Startup and training can be performed in an acceptable period of time. Operators at RMA already have experience with most of the components of this system.

The alternative is expected to be reliable. In situ pilot-scale tracer and biodegradation studies are required to determine whether in situ biodegradation can be implemented. The in situ treatment system requires simple equipment that is easily installed, and operation primarily involves monitoring and feed adjustments. All systems allow temporary maintenance to be

performed with minimal impacts to the schedule of operation. In many cases, maintenance can be performed without shutting down the system. The systems have automated controls that ensure continued operation with little supervision. The groundwater and the treatment system are adequately monitored during and after remediation.

GAC and air stripper packing are produced and supplied in sufficient quantities by qualified vendors. GAC vendors are responsible for the transportation of GAC. The sludge containing inorganics is stabilized and disposed, along with bag filters, in the on-post RCRA landfill. Precious metals are recovered from spent catalyst by the supply vendor.

8.9.2.7 Cost

The capital cost of this treatment system (including both phases of operation) is estimated to be $7,540,000. Approximate annual O&M costs years 1 to 5, which include LNAPL treatment and monitoring, are $550,000. The annual O&M costs for years 6 to 10, including monitoring, are $539,000. The annual O&M costs for years 11 to 30, including monitoring, are $853,000. The present worth cost for 30 years of remediation is $18,800,000. A cost summary is presented in Appendix A, Table A5-9.

8.10 ALTERNATIVE SPC-7/SPT-3/SPT-5: MASS REDUCTION/DEWATERING/CAP, OXIDATION/SORPTION, IN SITU BIODEGRADATION

This alternative consists of groundwater extraction from the South Plants North Source, South Plants Southeast, and South Tank Farm Plumes. Extraction is completed in a mass reduction configuration at the South Plants North Source and South Plants Southeast Plumes. LNAPL in the South Tank Farm Plume is removed by a dual-pump system. The South Tank Farm Plume is treated with in situ biodegradation. A dewatering grid is added after mass reduction is complete and soils and structures remediation activities are completed. The soils remediation includes a cap over the South Plants Central Processing Area. Extracted water is treated with oxidation and GAC adsorption and is then reinjected into two recharge trenches located in Section 27. Tables 8.4-1 and 8.6-1 list the estimated chemical influent concentrations for the first

phase (mass reduction) of this alternative. The concentrations are the same as those in Alternative SPC-5/SPT-2/SPT-5 (Section 8.6). Table 8.9-1 lists the estimated chemical influent concentrations for the second phase (dewatering) with a cap in place.

8.10.1 Description of Alternative

8.10.1.1 Extraction/Reinjection

This alternative includes the same groundwater control systems that are used for Alternative SPC-6/SPT-2/SPT-5 (Section 8.7.1).

8.10.1.2 Treatment

The extracted groundwater is treated using two methods in this phased approach. During the first phase (mass reduction), the groundwater is treated by a combination of in situ biodegradation of the South Tank Farm Plume and treatment of the South Plants North Source and South Plants Southeast Plumes by the preferred Basin A alternative treatment system. Any LNAPL removed from the plumes is drummed for eventual off-post incineration. The description of this treatment scenario is identical to that given for Alternative SPC-5/SPT-2/SPT-5 in Section 8.6.2. This treatment continues for 10 years based on volumetric estimates of water removal needed to significantly reduce the contaminant mass in groundwater in the centers of the plumes.

In year 10, a treatment system is assembled in South Plants to treat the water extracted in the second phase (dewatering), which commences in year 11. This treatment system uses oxidation followed by GAC adsorption at a rate of 25 gpm, which is identical to the second phase of Alternative SPC-6/SPT-3/SPT-5, Section 8.8.1.2.

8.10.1.3 Sidestreams

The sidestreams generated in the first phase of this alternative are as described in Alternative SPC-5/SPT-2/SPT-5 (Section 8.6.1.3). The second phase of this alterative generates the same sidestreams as the second phase of Alternative SPC-6/SPT-3/SPT-5 (Section 8.8.1.3).

8.10.2 Analysis of Alternative

8.10.2.1 Overall Protection of Human Health and the Environment

This alternative, combined with continued operation of the boundary systems, provides protection of human health and the environment. Removal of VHOs, benzene, DBCP, OCPs, and LNAPL from the groundwater in the South Plants North Source and South Plants Southeast Plumes and biodegradation of the benzene in the South Tank Farm Plume results in a reduction in the contaminant mass in the environment and eventually reduces the loading on the boundary system. Extended dewatering of the South Plants plumes results in further removal of chloroform, benzene, and DBCP.

The permanent removal of the contaminants reduces the volume and toxicity of the contaminated groundwater and reduces the migration of the contaminants. A significant mass of contaminants is removed from the centers of the plumes in the first 10 years based on estimates of the volume of highly contaminated groundwater found in the central portions of the plumes. Continued monitoring after the demobilization of the mass removal system assesses whether 10 years of mass removal has permanently reduced the toxicity of the groundwater. A dewatering grid further removes remaining contamination and reduces the groundwater mound, hence controlling groundwater flow. Therefore, the possibility for contaminant migration is reduced, as is the amount of contaminated soil in contact with the groundwater. The leaching of contaminants from the South Plants Central Processing Area is reduced by the installation of a cap, thus suspending contaminants in the vadose zone following dewatering.

8.10.2.2 Compliance with ARARS

This remedial alternative is in compliance with all potential action-specific ARARs listed in the Technology Description Volume, Appendix A, including those related to the extraction systems and air emission controls, because it involves extraction well systems and groundwater treatment systems that comply with these ARARs. Recovery, transportation, and off-site treatment of LNAPL from the South Tank Farm Plume also comply with these potential ARARs. The treatment systems also comply with all potential chemical-specific ARARs listed in Appendix A,

Volume I of the Water DSA, and with the FFA. PRGs are achieved at the RMA boundary through continued operation of the boundary systems. Operation of the extraction well systems and continued operation of the boundary systems, along with appropriate siting of the common Basin A/South Plants groundwater treatment plant, ensure compliance with all potential location-specific ARARs applicable to groundwater, which are listed in Appendix A, Volume I of the Water DSA, and with the FFA.

8.10.2.3 Long-Term Effectiveness and Permanence

This alternative reduces the potential for off-post exposure by removing and treating contaminants at the source. In situ biotreatment of the South Tank Farm Plume ensures that benzene levels throughout the aquifer are significantly and permanently reduced. The mass removal of contaminants reduces the potential for increased loading at the boundary systems, and the dewatering system controls the flow of contaminants and minimizes migration to the west and northwest, the primary directions of flow. Treatment and reinjection of the extracted groundwater from the dewatering continues. Dewatering suspends the contaminants in the vadose zone during dewatering when the water table is lowered. The cap reduces the leaching of those contaminants suspended in the vadose zone. Long-term effectiveness and plume migration are evaluated through continued groundwater monitoring.

8.10.2.4 Reduction of TMV

This alternative reduces the TMV of contaminated groundwater by mass removal of the contaminants with extraction wells at the centers of the plumes. The groundwater intercepted at the South Plants North Source and South Plants Southeast Plumes is treated by a combination of air stripping and GAC adsorption at a rate of 2 gpm. In the second phase, oxidation transfers some volatile organics from the water phase to the air phase where they are subsequently transferred to vapor-phase GAC. Residual contaminants (OCPs, DBCP, and volatile organics) in the water are adsorbed onto GAC. Saturated vapor- and liquid-phase GAC require off-post thermal regeneration.

In situ biotreatment, involving recirculation of 10 gpm of water from the South Tank Farm, significantly reduces the toxicity and volume of contaminants, thereby further reducing contaminant migration from the South Tank Farm area. LNAPL is separated and collected for eventual off-post incineration.

After the mass reduction phase is complete, the remaining contamination is further immobilized by the reduction of the South Plants groundwater mound. The water table is lowered due to decreased man-made recharge and to dewatering, thereby reducing the amount of contaminated soil in contact with the groundwater. The cap reduces the leaching of the contaminants suspended in the soil column under the South Plants Central Processing Area. The migration of the contaminants is reduced when the hydraulic heads are lowered, most of the remaining contamination is collected by the dewatering system and treated.

The groundwater extracted from the South Plants dewatering wells is treated by a combination of oxidation and GAC adsorption at a rate of 25 gpm. Oxidation decomposes DBCP, VAOs, and a major fraction of the VHOs. The residual contaminants (mainly OCPs) in the water are adsorbed onto GAC. Saturated GAC requires off-post thermal regeneration. Any VHOs stripped out of the oxidation reactor in the ozone off gas is transferred to vapor-phase GAC, which requires off-post thermal regeneration.

Since the contaminants in the South Plants plumes are removed from the groundwater prior to reinjection, the treatment is irreversible. A large fraction of the contaminants in the South Tank Farm Plume are destroyed by in situ biodegradation. Some contaminants remain in the South Plants plumes because a fraction of the flow containing contaminants may not be removed by the extraction system, because a fraction of the contaminants may not biodegrade, and because some contaminants may remain sorbed to the soil in the aquifer and desorb at a later time.

8.10.2.5 Short-Term Effectiveness

In general, the construction, operation, and final demobilization of this alternative have minimal negative impact on the environment, workers, and the surrounding community. On-post workers would potentially be exposed to contaminants through dermal contact and dust inhalation during excavation when constructing the recharge trenches. To minimize or prevent such exposure, dust control measures and PPE are used. Personnel must follow specified procedures when repairing or operating the ozone generator or when changing out the GAC system. To reduce potential exposure, personnel are made aware of health and safety procedures and PPE is used.

In situ biotreatment has minimal negative impact on the environment, workers, and the surrounding community since treatment is carried out in the subsurface environment. Operation of the system involves some chemical handling that requires PPE.

RAOs are achieved under this alternative. The time required to complete this remedial action may be more than 100 years.

8.10.2.6 Implementability

This alternative is composed of both well-developed technologies (extraction wells, air stripping, vapor- and liquid-phase GAC adsorption, and reinjection trenches) and innovative technologies (in situ biological treatment and hydrogen peroxide-ozone oxidation). As discussed in Sections 5, 11.3, 14.1, 14.2, 14.3, and 15, of the Technology Description Volume, most of these technologies are being used successfully at RMA. The equipment required is commercially available from several vendors. Extraction systems, transport systems, and reinjection systems are implementable, time-proven technologies currently in use at RMA. The water treatment system from the preferred Basin A remedial alternative is capable of handling the 2-gpm flow from the South Plants North Source and South Plants Southeast Plumes during the first phase (mass reduction). The groundwater from these plumes is similar in quality to the groundwater from the Basin A plumes and can therefore be mixed without upsetting the preferred Basin A treatment alternative (Section 7.3.1.2).

The water treatment system required for treating the South Plants groundwater during the dewatering phase can be assembled on skids prior to shipment to the site. Startup and training can be performed in an acceptable period of time, and operators at RMA already have experience with most of the components of this system.

The alternative is expected to be reliable. In situ pilot-scale tracer and biodegradation studies are required to determine whether in situ biodegradation can be implemented. The in situ treatment system requires simple equipment that is easily installed. Operation is primarily associated with monitoring and feed adjustments. All systems allow temporary maintenance to be performed with minimal impacts to the schedule of operation. In many cases, maintenance can be performed without shutting down the system. The systems have automated controls that ensure continued operation with little supervision. The groundwater and the treatment system are adequately monitored during and after remediation.

GAC and hydrogen peroxide are produced and supplied in sufficient quantities by qualified vendors. GAC vendors are responsible for the transportation of GAC. The sludge containing inorganics is stabilized and disposed, along with bag filters, in the on-post RCRA landfill. Precious metals are recovered from spent catalyst by the supply vendor.

8.10.2.7 Cost

The capital cost of this treatment system (including both phases of operation) is estimated to be $7,680,000. Approximate annual O&M costs for years 1 to 5, which include LNAPL disposal, and monitoring, are $550,000. The annual O&M costs for years 6 to 10, including monitoring, are $539,000. The annual O&M costs for years 11 to 30, including monitoring, are $856,000. The present worth cost for 30 years of remediation is $18,900,000. A summary of cost is presented in Appendix A, Table A5-10.

Criteria	ALT SPC-1 No Action
1. Overall protection of human health and the environment	Contaminants free to migrate to boundary, are treated at boundary systems
2. Compliance with ARARs –Action-specific –Location-specific –Chemical-specific –Criteria, advisories, and guidance	Complies with location-, chemical-specific ARARs, and FFA if boundary systems continue to operate Action-specific ARARs do not apply
3. Long-term effectiveness and permanence –Magnitude and residual risks –Adequacy and reliability of controls	Increases potential for exposure due to contaminant migration and for additional loading on boundary systems Monitoring continues No controls implemented
4. Reduction of TMV through treatment –Treatment process used and materials treated –Degree and quantity of TMV reduction –Irreversibility of TMV reduction	No treatment or action undertaken, contaminants free to migrate TMV reduced slightly over time by natural attenuation
5. Short-term effectiveness –Protection of workers during remedial action –Protection of community during remedial action –Environmental impacts of remedial action –Time until RAOs are achieved	Minimal negative impact on the environment, surrounding community, and workers Contamination free to migrate to boundary RAOs achieved if boundary systems continue to operate
6. Implementability –Technical feasibility –Administrative feasibility –Availability of services and materials	Technically and administratively feasible Easily implemented
7. Costs	
–Capital Cost	$0
–Annual O&M Cost	$114,000
–Present Worth	$1,800,000

Table 8.0-1 Comparative Analysis of Alternatives: South Plants Plume Group

Criteria	ALT SPC-3/SPT-2 Mass Reduction, Stripping/Sorption	ALT SPC-3/SPT-3 Mass Reduction, Oxidation/Sorption
1. Overall protection of human health and the environment	Removes contaminant mass from the environment	Removes contaminant mass from the environment
2. Compliance with ARARs –Action-specific –Location-specific –Chemical-specific –Criteria, advisories, and guidance	Complies with action-, location-, and chemical-specific ARARs	Complies with action-, location-, and chemical-specific ARARs
3. Long-term effectiveness and permanence –Magnitude and residual risks –Adequacy and reliability of controls	Minimizes potential for off-post exposure, contaminants removed and treated at source; reduced potential for increased loading at boundary systems; does not decrease groundwater mound Monitoring program continues	Minimizes potential for off-post exposure, contaminants removed and treated at source; reduced potential for increased loading at boundary systems; does not decrease groundwater mound Monitoring program continues
4. Reduction of TMV through treatment –Treatment process used and materials treated –Degree and quantity of TMV reduction –Irreversibility of TMV reduction	Contaminants removed by air stripping and GAC adsorption; LNAPL removed and destroyed by off-post incineration; mass reduction system at source reduces potential migration through the aquifer 8 gpm removed and treated Contaminants irreversibly transferred to GAC, which requires regeneration, or transferred to vapor phase where destroyed by catalytic oxidation	Contaminants removed by oxidation and GAC adsorption; LNAPL removed and destroyed by off-post incineration; mass reduction system at source reduces potential migration through the aquifer 8 gpm removed and treated Contaminants destroyed by oxidation or transferred to GAC, which requires regeneration; lower GAC consumption than SPT-2; oxidation reactor emissions destroyed by catalytic oxidation
5. Short-term effectiveness –Protection of workers during remedial action –Protection of community during remedial action –Environmental impacts of remedial action –Time until RAOs are achieved	Minimal negative impact on the environment, surrounding community, and workers Achieves RAOs; operates for 10 years	Minimal negative impact on the environment, surrounding community, and workers Achieves RAOs; operates for 10 years
6. Implementability –Technical feasibility –Administrative feasibility –Availability of services and materials	Technically feasible: demonstrated, available technologies, reliable equipment, and experienced operators Administratively feasible	Technically feasible: GAC is a demonstrated, available technology, with reliable equipment and experienced operators; advanced oxidation process is innovative, requiring more oversight and operator training Administratively feasible
7. Costs		
–Capital Cost	$3,730,000	$4,090,000
–Annual O&M Cost	$693,000	$650,000
–Present Worth	$10,500,000	$10,500,000

Criteria	ALT SPC-3/SPT-2/SPT-4 Mass Reduction, Stripping/Sorption, Biological Reactor/Sorption	ALT SPC-3/SPT-3/SPT-4 Mass Reduction, Oxidation/Sorption, Biological Reactor/Sorption
1. Overall protection of human health and the environment	Removes contaminant mass from the environment	Removes contaminant mass from the environment
2. Compliance with ARARs –Action-specific –Location-specific –Chemical-specific –Criteria, advisories, and guidance	Complies with action-, location-, and chemical-specific ARARs	Complies with action-, location-, and chemical-specific ARARs
3. Long-term effectiveness and permanence –Magnitude and residual risks –Adequacy and reliability of controls	Minimizes potential for off-post exposure, contaminants removed and treated at source; reduced potential for increased loading at boundary systems; does not decrease groundwater mound Monitoring program continues	Minimizes potential for off-post exposure, contaminants removed and treated at source; reduced potential for increased loading at boundary systems; does not decrease groundwater mound Monitoring program continues
4. Reduction of TMV through treatment –Treatment process used and materials treated –Degree and quantity of TMV reduction –Irreversibility of TMV reduction	Contaminants removed by air stripping and GAC adsorption at South Plants North Source and South Plants Southeast Plumes; direct biological treatment of the contaminants in the South Tank Farm Plume; LNAPL removed by skimming and destroyed by off-post incineration; mass reduction system at source reduces potential migration through the aquifer 5 gpm from South Plants North Source and South Plants Southeast Plumes and 5 gpm from South Tank Farm Plume removed and treated Contaminants irreversibly transferred to GAC, which requires regeneration, transferred to vapor phase by air stripping, or destroyed in biological reactor, creating sludge that requires disposal; emissions from air stripper and biological reactor destroyed by catalytic oxidation	Contaminants removed by oxidation and GAC adsorption at South Plants North Source and South Plants Southeast Plumes; direct biological treatment of contaminants in the South Tank Farm Plume; LNAPL removed by skimming and destroyed by off-post incineration; mass removal at source reduces potential migration through the aquifer 5 gpm from South Plants North Source and South Plants Southeast Plumes and 5 gpm from South Tank Farm Plume removed and treated Contaminants destroyed in oxidation or biological reactor or transferred to GAC, which requires regeneration; biological treatment creates sludge, which requires disposal; lower GAC consumption than SPT-2; oxidation and biological reactor emissions destroyed by catalytic oxidation
5. Short-term effectiveness –Protection of workers during remedial action –Protection of community during remedial action –Environmental impacts of remedial action –Time until RAOs are achieved	Minimal negative impact on the environment, surrounding community, and workers Achieves RAOs; both systems operate for 10 years	Minimal negative impact on the environment, surrounding community and workers Achieves RAOs; both systems operate for 10 years
6. Implementability –Technical feasibility –Administrative feasibility –Availability of services and materials	Technically feasible: demonstrated, available technologies; most equipment reliable except biological process requires close oversight and additional training for operators Administratively feasible	Technically feasible: GAC is a demonstrated, available technology with reliable equipment and experienced operators; advanced oxidation process is innovative; oxidation and biological reactors require more oversight and additional operator training Administratively feasible

Criteria	ALT SPC-3/SPT-2/SPT-4 Mass Reduction, Stripping/Sorption, Biological Reactor/Sorption	ALT SPC-3/SPT-3/SPT-4 Mass Reduction, Oxidation/Sorption, Biological Reactor/Sorption
7. Costs		
–Capital Cost	$4,390,000	$5,650,000
–Annual O&M Cost	$820,000	$826,000
–Present Worth	$12,200,000	$13,500,000

Criteria	ALT SPC-5/SPT-2/SPT-5 Mass Reduction, Stripping/Sorption, In Situ Biodegradation
1. Overall protection of human health and the environment	Removes contaminant mass from the environment
2. Compliance with ARARs –Action-specific –Location-specific –Chemical-specific –Criteria, advisories, and guidance	Complies with action-, location-, and chemical-specific ARARs
3. Long-term effectiveness and permanence –Magnitude and residual risks –Adequacy and reliability of controls	Minimizes potential for off-post exposure, contaminants removed and treated at source; reduced potential for increased loading at boundary systems; does not decrease groundwater mound Monitoring program continues
4. Reduction of TMV through treatment –Treatment process used and materials treated –Degree and quantity of TMV reduction –Irreversibility of TMV reduction	Contaminants removed by air stripping and GAC adsorption at South Plants North Source and South Plants Southeast Plumes; in situ biological treatment of the contaminants in the South Tank Farm Plume; LNAPL removed and destroyed by off-post incineration; mass reduction system at source reduces potential migration through the aquifer 2 gpm from South Plants North Source and South Plants Southeast Plumes extracted and treated and 10 gpm from South Tank Farm Plume recirculated and treated by in situ biodegradation Contaminants irreversibly transferred to GAC, which requires regeneration; transferred to vapor phase where destroyed by catalytic oxidation; or destroyed by in situ biodegradation
5. Short-term effectiveness –Protection of workers during remedial action –Protection of community during remedial action –Environmental impacts of remedial action –Time until RAOs are achieved	Minimal negative impact on the environment, surrounding community, and workers Achieves RAOs; both systems operate for 10 years
6. Implementability –Technical feasibility –Administrative feasibility –Availability of services and materials	Technically feasible: demonstrated, available technologies except in situ biological treatment; biological process requires close oversight Administratively feasible

Criteria	ALT SPC-5/SPT-2/SPT-5 Mass Reduction, Stripping/Sorption, In Situ Biodegradation
7. Costs	
–Capital Cost	$4,280,000
–Annual O&M Cost	$538,000
–Present Worth	$10,500,000

Table 8.0-1 Comparative Analysis of Alternatives: South Plants Plume Group

Criteria	ALT SPC-6/SPT-2/SPT-5 Mass Reduction/Dewatering, Stripping/Sorption, In Situ Biodegradation	ALT SPC-6/SPT-3/SPT-5 Mass Reduction/Dewatering, Oxidation/Sorption, In Situ Biodegradation
1. Overall protection of human health and the environment	Removes contaminant mass from the environment and provides long-term control of contaminant migration	Removes contaminant mass from the environment and provides long-term control of contaminant migration
2. Compliance with ARARs –Action-specific –Location-specific –Chemical-specific –Criteria, advisories, and guidance	Complies with action-, location-, and chemical-specific ARARs	Complies with action-, location-, and chemical-specific ARARs
3. Long-term effectiveness and permanence –Magnitude and residual risks –Adequacy and reliability of controls	Minimizes potential for off-post exposure, contaminants removed and treated at source; reduced potential for increased loading at boundary systems; decreases groundwater mound, reducing potential for long-term migration Monitoring program continues	Minimizes potential for off-post exposure, contaminants removed and treated at source; reduced potential for increased loading at boundary systems; decreases groundwater mound, reducing potential for long-term migration Monitoring program continues
4. Reduction of TMV through treatment –Treatment process used and materials treated –Degree and quantity of TMV reduction –Irreversibility of TMV reduction	Benzene destroyed by in situ biodegradation in the South Tank Farm Plume. Contaminants from South Plants North Source and South Plants Southeast Plumes removed by air stripping and GAC adsorption; LNAPL removed and destroyed by off-post incineration; mass reduction system at source combined with mound dewatering reduces potential migration through the aquifer 10 gpm recirculated for in situ biotreatment and 2 gpm extracted and treated for mass reduction followed by 30 gpm extracted and treated for dewatering Contaminants irreversibly destroyed by biodegradation; transferred to GAC, which requires regeneration; or transferred to vapor-phase and destroyed by catalytic oxidation	Benzene destroyed by in situ biodegradation in the South Tank Farm Plume. Contaminants from South Plants North Source and South Plants Southeast Plumes removed by oxidation and GAC adsorption; LNAPL removed and destroyed by off-post incineration; mass reduction at source followed by mound dewatering reduces potential migration through the aquifer 10 gpm recirculated for in situ biotreatment and 2 gpm extracted for mass reduction followed by 30 gpm for dewatering Contaminants irreversibly destroyed by biodegradation or oxidation or transferred to GAC, which requires regeneration; lower GAC consumption than SPT-2; oxidation reactor emissions treated by vapor-phase GAC adsorption
5. Short-term effectiveness –Protection of workers during remedial action –Protection of community during remedial action –Environmental impacts of remedial action –Time until RAOs are achieved	Minimal negative impact on the environment, surrounding community, and workers Achieves RAOs; mass reduction requires 10 years of operation followed by dewatering that may be required for more than 100 years	Minimal negative impact on the environment, surrounding community, and workers Achieves RAOs; mass reduction requires 10 years of operation followed by dewatering that may be required for more than 100 years

Criteria	ALT SPC-6/SPT-2/SPT-5 Mass Reduction/Dewatering, Stripping/Sorption, In Situ Biodegradation	ALT SPC-6/SPT-3/SPT-5 Mass Reduction/Dewatering, Oxidation/Sorption, In Situ Biodegradation
6. Implementability –Technical feasibility –Administrative feasibility –Availability of services and materials	Technically feasible: demonstrated, available technologies, reliable equipment, and experienced operators Administratively feasible	Technically feasible: GAC is a demonstrated, available technology; advanced oxidation is innovative, requiring more oversight and additional training for operators Administratively feasible
7. Costs		
–Capital Cost	$6,100,000	$7,680,000
–Annual O&M Cost	$864,000	$874,000
–Present Worth	$17,400,000	$19,100,000

Criteria	SPC-7/SPT-2/SPT-5 Mass Reduction/Dewatering/Cap, Stripping/Sorption, In Situ Biodegradation	ALT SPC-7/SPT-3/SPT-5 Mass Reduction/Dewatering/Cap, Oxidation/Sorption, In Situ Biodegradation
1. Overall protection of human health and the environment	Removes contaminant mass from the environment and provides long-term control of contaminant migration	Removes contaminant mass from the environment and provides long-term control of contaminant migration
2. Compliance with ARARs –Action-specific –Location-specific –Chemical-specific –Criteria, advisories, and guidance	Complies with action-, location-, and chemical-specific ARARs	Complies with action-, location-, and chemical-specific ARARs
3. Long-term effectiveness and permanence –Magnitude and residual risks –Adequacy and reliability of controls	Minimizes potential for off-post exposure, contaminants removed and treated at source; reduced potential for increased loading at boundary systems; decreases groundwater mound, reducing potential for long-term migration; reduces infiltration Monitoring program continues	Minimizes potential for off-post exposure, contaminants removed and treated at source; reduced potential for increased loading at boundary systems; decreases groundwater mound, reducing potential for long-term migration; reduces infiltration Monitoring program continues
4. Reduction of TMV through treatment –Treatment process used and materials treated –Degree and quantity of TMV reduction –Irreversibility of TMV reduction	Benzene destroyed by in situ biodegradation in the South Tank Farm Plume Contaminants removed by air stripping and GAC adsorption in the remainder of the South Plants plumes; LNAPL removed and destroyed by off-post incineration; mass reduction at source followed by dewatering reduces potential migration through the aquifer; cap reduces recharge and contaminant mobility	Benzene destroyed by in situ biodegradation in the South Tank Farm Plume Contaminants removed by oxidation and GAC adsorption in the remainder of the South Plants plumes; LNAPL removed and destroyed by off-post incineration; mass reduction system at source followed by dewatering reduces potential migration through the aquifer; cap reduces recharge and contaminant mobility
	10 gpm recirculated for in situ biotreatment and 2 gpm extracted and treated for mass reduction followed by 25 gpm for dewatering removed and treated	10 gpm recirculated for in situ biotreatment and 2 gpm extracted and treated for mass reduction followed by 25 gpm for dewatering removed and treated
	Contaminants irreversibly destroyed by biodegradation and transferred to GAC, which requires regeneration, or transferred to vapor phase and destroyed by catalytic oxidation	Contaminants irreversibly destroyed by biodegradation and transferred to GAC, which requires regeneration or destroyed by oxidation; lower GAC consumption than SPT-2; oxidation reactor emissions treated by vapor-phase GAC adsorption.

Criteria	SPC-7/SPT-2/SPT-5 Mass Reduction/Dewatering/Cap, Stripping/Sorption, In Situ Biodegradation	ALT SPC-7/SPT-3/SPT-5 Mass Reduction/Dewatering/Cap, Oxidation/Sorption, In Situ Biodegradation
5. Short-term effectiveness –Protection of workers during remedial action –Protection of community during remedial action –Environmental impacts of remedial action –Time until RAOs are achieved	Minimal negative impact on the environment, surrounding community and workers Achieves RAOs; mass reduction requires 10 years of operation followed by dewatering that may be required for more than 100 years	Minimal negative impact on the environment, surrounding community, and workers Achieves RAOs; mass reduction requires 10 years of operation followed by dewatering that may be required for more than 100 years
6. Implementability –Technical feasibility –Administrative feasibility –Availability of services and materials	Technically feasible: demonstrated, available technologies, reliable equipment, and experienced operators Administratively feasible	Technically feasible: demonstrated, available technologies; reliable equipment; advanced oxidation process is innovative and requires increased oversight and additional training for operators Administratively feasible
7. Costs		
–Capital Cost	$7,540,000*	$7,680,000*
–Annual O&M Cost	$853,000	$856,000
–Present Worth	$18,800,000	$18,900,000

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* Does not include cost of cap

ARARs	Applicable or Relevant and Appropriate Requirements
FFA	Federal Facility Agreement
GAC	Granular Activated Carbon
LNAPL	Light Nonaqueous Phase Liquid
O&M	Operation and Maintenance
RAO	Remedial Action Objective
TMV	Toxicity, Mobility, or Volume

Table 8.2-1 [illegible] South Plants North Source, South Plants Southeast, and South Tank [illegible] Plumes Estimated Influent Concentrations

Chemical Group / Compound	Estimated Influent Concentration (ug/l)	Target Effluent Concentration (ug/l)
Volatile Halogenated Organic Compounds (VHOs)		
1,2-Dichloroethane	0.50	10
1,1-Dichloroethylene	1.6	14
1,1,1-Trichloroethane	0.84	400
1,1,2-Trichloroethane	0.33	6
Carbon tetrachloride	13.	10
Chlorobenzene	19.	50
Chloroform	620.	30
Methylene chloride	10.	10
Tetrachloroethylene	15.	10
Trichloroethylene	5.3	10
Volatile Hydrocarbon Compounds (VHCs)		
Dicyclopentadiene	24.	92
Volatile Aromatic Organic Compounds (VAOs)		
Benzene	28000.	10
Ethylbenzene	3.3	1360
o-and p-Xylene	7.6	20000
Toluene	14.	2000
Organosulfur Compounds, Mustard Agent Related (OSCMs)		
1,4-Oxathiane	1.5	320
Dithiane	1.2	36
Organosulfur Compounds, Herbicide Related (OSCHs)		
Chlorophenylmethyl sulfide	5.0	60
Chlorophenylmethyl sulfone	9.8	72
Chlorophenylmethyl sulfoxide	3.3	72
Organophosphorous Compounds, GB-Agent Related (OPHGBs)		
Diisopropylmethyl phosphonate	1.8	1200
Organophosphorus Compounds, Pesticide Related (OPHPs)		
Atrazine	1.2	8.06
Dibromochloropropane (DBCP)		
Dibromochloropropane	3.8	0.40
Semivolatile Halogenated Organic Compounds (SHOs)		
Hexachlorocylopentadiene	0.65	0.46

Table 8.2-1 S[illegible] South Plants North Source, South Plants Southeast, and South Tank [illegible] Plumes Estimated Influent Concentrations

Chemical Group / Compound	Estimated Influent Concentration (ug/l)	Target Effluent Concentration (ug/l)
Organochlorine Pesticides (OCPs)		
Aldrin	0.18	0.10
Chlordane	0.27	4
PPDDE	0.03	0.11
PPDDT	0.04	0.20
Dieldrin	0.13	0.10
Endrin	0.08	0.40
Isodrin	0.07	0.12
Arsenic		
Arsenic	3.0	100
Mercury		
Mercury	0.25	4
ICP Metals		
Cadmium	2.4	10
Chromium	9.5	200
Lead	3.9	100

Table 8.4-1 [illegible]3 South Plants North Source, and Southeast Plumes Estimated Influen[illegible]centrations

Chemical Group / Compound	Estimated Influent Concentration (ug/l)	Target Effluent Concentration (ug/l)
Volatile Halogenated Organic Compounds (VHOs)		
1,2-Dichloroethane	0.56	10
1,1-Dichloroethylene	3.7	14
1,1,1-Trichloroethane	1.0	400
1,1,2-Trichloroethane	1.3	6
Carbon tetrachloride	45.	10
Chlorobenzene	51.	50
Chloroform	2400.	30
Methylene chloride	31.	10
Tetrachloroethylene	51.	10
Trichloroethylene	16.	10
Volatile Hydrocarbon Compounds (VHCs)		
Dicyclopentadiene	40.	92
Volatile Aromatic Organic Compounds (VAOs)		
Benzene	220.	10
Ethylbenzene	2.7	1360
o-and p-Xylene	8.0	20000
Toluene	27.	2000
Organosulfur Compounds, Mustard Agent Related (OSCMs)		
1,4-Oxathiane	3.7	320
Dithiane	4.6	36
Organosulfur Compounds, Herbicide Related (OSCHs)		
Chlorophenylmethyl sulfide	16.	60
Chlorophenylmethyl sulfone	25.	72
Chlorophenylmethyl sulfoxide	7.7	72
Organophosphorous Compounds, GB-Agent Related (OPHGBs)		
Diisopropylmethyl phosphonate	7.0	1200
Organophosphorus Compounds, Pesticide Related (OPHPs)		
Atrazine	3.6	8.06
Dibromochloropropane (DBCP)		
Dibromochloropropane	14.	0.40
Semivolatile Halogenated Organic Compounds (SHOs)		
Hexachlorocylopentadiene	1.1	0.46

Table 8.4-1 S[illegible] South Plants North Source, and Southeast Plumes Estimated Influent [illegible]centrations

Chemical Group / Compound	Estimated Influent Concentration (ug/l)	Target Effluent Concentration (ug/l)
Organochlorine Pesticides (OCPs)		
Aldrin	0.46	0.10
Chlordane	0.53	4
PPDDE	0.10	0.11
PPDDT	0.08	0.20
Dieldrin	0.25	0.10
Endrin	0.19	0.40
Isodrin	0.18	0.12
Arsenic		
Arsenic	11.	100
Mercury		
Mercury	0.37	4
ICP Metals		
Cadmium	2.1	10
Chromium	7.3	200
Lead	15.	100

Table 8.4-2 S[illegible] South Tank Farm Direct Biological Treatment Estimated Influent Co[illegible]rations

Chemical Group / Compound	Estimated Influent Concentration (ug/l)	Target Effluent Concentration (ug/l)
Volatile Halogenated Organic Compounds (VHOs)		
1,2-Dichloroethane	0.59	10
1,1-Dichloroethylene	1.1	14
1,1,1-Trichloroethane	0.94	400
Carbon tetrachloride	2.0	10
Chlorobenzene	9.2	50
Chloroform	2.0	30
Methylene chloride	3.3	10
Tetrachloroethylene	1.8	10
Trichloroethylene	2.1	10
Volatile Hydrocarbon Compounds (VHCs)		
Dicyclopentadiene	23.	92
Volatile Aromatic Organic Compounds (VAOs)		
Benzene	46000.	10
Ethylbenzene	4.2	1360
o-and p-Xylene	9.0	20000
Toluene	11.	2000
Organosulfur Compounds, Mustard Agent Related (OSCMs)		
1,4-Oxathiane	0.82	320
Organosulfur Compounds, Herbicide Related (OSCHs)		
Chlorophenylmethyl sulfide	1.4	60
Chlorophenylmethyl sulfone	5.5	72
Chlorophenylmethyl sulfoxide	2.2	72
Organophosphorus Compounds, Pesticide Related (OPHPs)		
Atrazine	0.47	8.06
Dibromochloropropane (DBCP)		
Dibromochloropropane	0.30	0.40
Semivolatile Halogenated Organic Compounds (SHOs)		
Hexachlorocylopentadiene	0.62	0.46
Organochlorine Pesticides (OCPs)		
Aldrin	0.10	0.10
Chlordane	0.21	4

Table 8.4-2 S[illegible] South Tank Farm Direct Biological Treatment Estimated Influent Co[illegible]rations

Chemical Group / Compound	Estimated Influent Concentration (ug/l)	Target Effluent Concentration (ug/l)
Organochlorine Pesticides (OCPs)		
PPDDT	0.04	0.20
Dieldrin	0.11	0.10
Endrin	0.05	0.40
Isodrin	0.03	0.12
Mercury		
Mercury	0.25	4
ICP Metals		
Cadmium	3.0	10
Chromium	13.	200

Table 8.6-1 [illegible]-5 South Tank Farm Plume In-Situ Biological Treatment Estimated In[illegible] Concentrations

Chemical Group / Compound	Estimated Influent Concentration (ug/l)	Target Effluent Concentration (ug/l)
Volatile Halogenated Organic Compounds (VHOs)		
1,2-Dichloroethane	0.59	10
1,1-Dichloroethylene	1.1	14
1,1,1-Trichloroethane	0.94	400
Carbon tetrachloride	2.0	10
Chlorobenzene	9.2	50
Chloroform	2.0	30
Methylene chloride	3.3	10
Tetrachloroethylene	1.8	10
Trichloroethylene	2.1	10
Volatile Hydrocarbon Compounds (VHCs)		
Dicyclopentadiene	23.	92
Volatile Aromatic Organic Compounds (VAOs)		
Benzene	46000.	10
Ethylbenzene	4.2	1360
o-and p-Xylene	9.0	20000
Toluene	11.	2000
Organosulfur Compounds, Mustard Agent Related (OSCMs)		
1,4-Oxathiane	0.82	320
Organosulfur Compounds, Herbicide Related (OSCHs)		
Chlorophenylmethyl sulfide	1.4	60
Chlorophenylmethyl sulfone	5.5	72
Chlorophenylmethyl sulfoxide	2.2	72
Organophosphorus Compounds, Pesticide Related (OPHPs)		
Atrazine	0.47	8.06
Dibromochloropropane (DBCP)		
Dibromochloropropane	0.30	0.40
Semivolatile Halogenated Organic Compounds (SHOs)		
Hexachlorocylopentadiene	0.62	0.46
Organochlorine Pesticides (OCPs)		
Aldrin	0.10	0.10
Chlordane	0.21	4

Table 8.6-1 [illegible]5 South Tank Farm Plume In-Situ Biological Treatment Estimated Inf[illegible] Concentrations [illegible]e 2 of 2

Chemical Group / Compound	Estimated Influent Concentration (ug/l)	Target Effluent Concentration (ug/l)
Organochlorine Pesticides (OCPs)		
PPDDT	0.04	0.20
Dieldrin	0.11	0.10
Endrin	0.05	0.40
Isodrin	0.03	0.12
Mercury		
Mercury	0.25	4
ICP Metals		
Cadmium	3.0	10
Chromium	13.	200

Table 8.6-2 A[illegible]SPC-5 Combined South Plants North Source, South Plants Southeast [illegible]es and Basin A Plume Group Estimated Influent Concentrations [illegible]e 1 of 2

Chemical Group / Compound	Estimated Influent Concentration (ug/l)	Target Effluent Concentration (ug/l)
Volatile Halogenated Organic Compounds (VHOs)		
1,2-Dichloroethane	6.7	10
1,1-Dichloroethylene	4.3	14
1,1,1-Trichloroethane	1.0	400
1,1,2-Trichloroethane	1.3	6
Carbon tetrachloride	7.6	10
Chlorobenzene	170.	50
Chloroform	6200.	30
Methylene chloride	89.	10
Tetrachloroethylene	93.	10
Trichloroethylene	22.	10
Volatile Hydrocarbon Compounds (VHCs)		
Dicyclopentadiene	22.	92
Volatile Aromatic Organic Compounds (VAOs)		
Benzene	570.	10
Ethylbenzene	1.8	1360
o-and p-Xylene	5.9	20000
Toluene	27.	2000
Organosulfur Compounds, Mustard Agent Related (OSCMs)		
1,4-Oxathiane	15.	320
Dithiane	39.	36
Organosulfur Compounds, Herbicide Related (OSCHs)		
Chlorophenylmethyl sulfide	30.	60
Chlorophenylmethyl sulfone	82.	72
Chlorophenylmethyl sulfoxide	11.	72
Organophosphorous Compounds, GB-Agent Related (OPHGBs)		
Diisopropylmethyl phosphonate	220.	1200
Isopropylmethyl phosphonic acid	100.	1400
Organophosphorus Compounds, Pesticide Related (OPHPs)		
Atrazine	6.0	8.06
Malathion	1.0	200
Dibromochloropropane (DBCP)		
Dibromochloropropane	4.4	0.40

Table 8.6-2 [illegible]SPC-5 Combined South Plants North Source, South Plants Southeast [illegible]es and Basin A Plume Group Estimated Influent Concentrations [illegible]e 2 of 2

Chemical Group / Compound	Estimated Influent Concentration (ug/l)	Target Effluent Concentration (ug/l)
Semivolatile Halogenated Organic Compounds (SHOs)		
1,3-Dichlorobenzene	0.84	13
Hexachlorocylopentadiene	0.39	0.46
Organochlorine Pesticides (OCPs)		
Aldrin	0.67	0.10
Chlordane	0.90	4
PPDDE	0.07	0.11
PPDDT	0.14	0.20
Dieldrin	0.39	0.10
Endrin	0.20	0.40
Isodrin	0.21	0.12
Arsenic		
Arsenic	40.	100
Mercury		
Mercury	0.47	4
ICP Metals		
Cadmium	4.0	10
Chromium	12.	200
Lead	9.5	100

Table 8.7-1 S South Plants Dewatering Estimated Influent Concentrations

Chemical Group / Compound	Estimated Influent Concentration (ug/l)	Target Effluent Concentration (ug/l)
Volatile Halogenated Organic Compounds (VHOs)		
1,2-Dichloroethane	0.41	10
1,1-Dichloroethylene	1.7	14
1,1,1-Trichloroethane	0.57	400
1,1,2-Trichloroethane	0.61	6
Carbon tetrachloride	15.	10
Chlorobenzene	8.7	50
Chloroform	190.	30
Methylene chloride	5.5	10
Tetrachloroethylene	8.4	10
Trichloroethylene	5.0	10
Volatile Hydrocarbon Compounds (VHCs)		
Dicyclopentadiene	24.	92
Volatile Aromatic Organic Compounds (VAOs)		
Benzene	7600.	10
Ethylbenzene	1.0	1360
o-and p-Xylene	3.3	20000
Toluene	7.2	2000
Organosulfur Compounds, Mustard Agent Related (OSCMs)		
1,4-Oxathiane	1.2	320
Dithiane	2.9	36
Organosulfur Compounds, Herbicide Related (OSCHs)		
Chlorophenylmethyl sulfide	2.8	60
Chlorophenylmethyl sulfone	9.6	72
Chlorophenylmethyl sulfoxide	3.1	72
Organophosphorous Compounds, GB-Agent Related (OPHGBs)		
Diisopropylmethyl phosphonate	1.5	1200
Organophosphorus Compounds, Pesticide Related (OPHPs)		
Atrazine	0.96	8.06
Malathion	0.16	200
Dibromochloropropane (DBCP)		
Dibromochloropropane	2.6	0.40

Table 8.7-1 [illegible]6 South Plants Dewatering Estimated Influent Concentrations

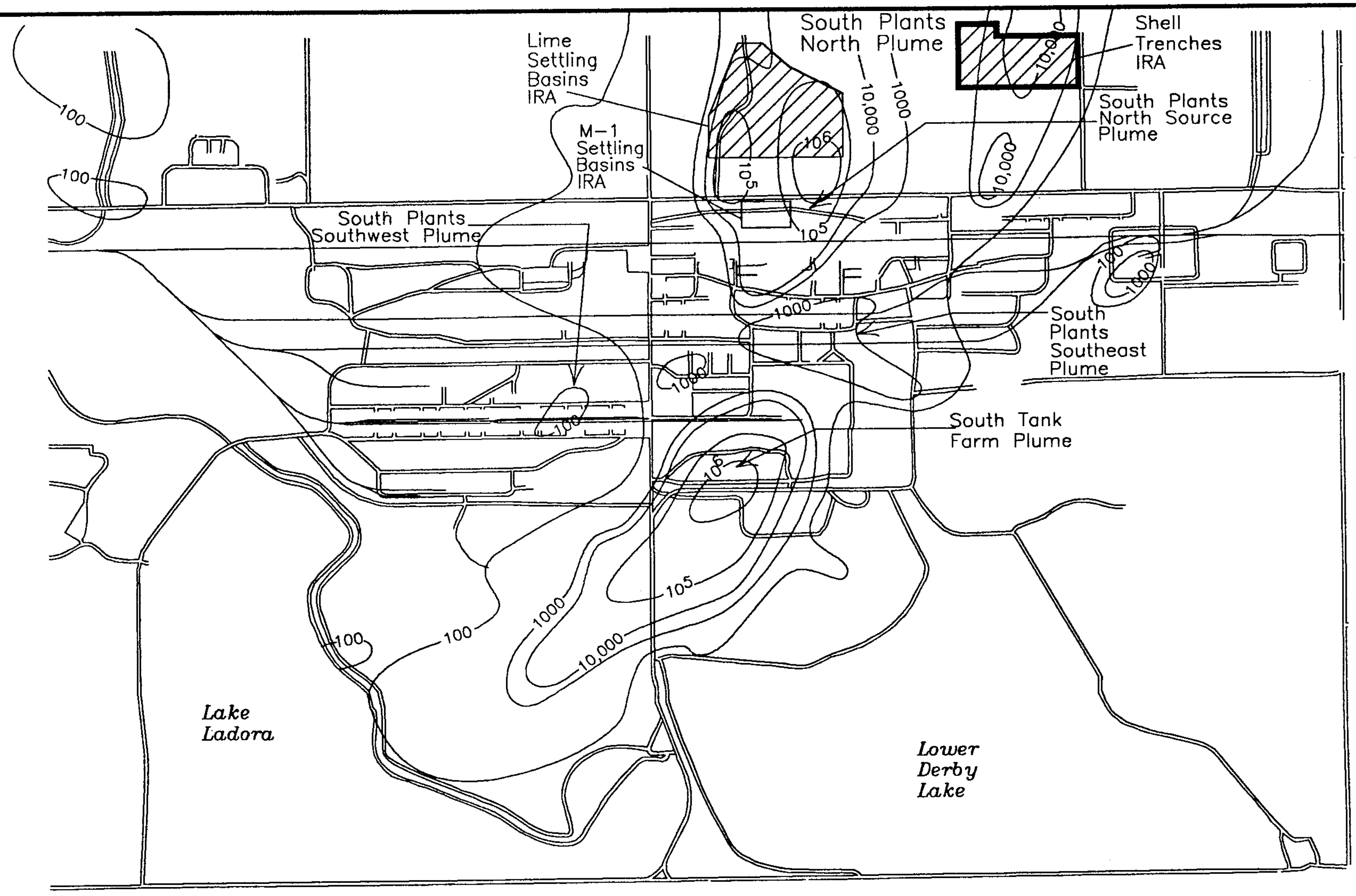
Chemical Group / Compound	Estimated Influent Concentration (ug/l)	Target Effluent Concentration (ug/l)
Semivolatile Halogenated Organic Compounds (SHOs)		
Hexachlorocylopentadiene	0.28	0.46
Organochlorine Pesticides (OCPs)		
Aldrin	0.11	0.10
Chlordane	0.11	4
Dichlorodiphenylethane (DDE)	0.03	0.11
Dichlorodiphenyltrichlorothane	0.04	0.20
Dieldrin	0.14	0.10
Endrin	0.09	0.40
Isodrin	0.04	0.12
Arsenic		
Arsenic	3.3	100
Mercury		
Mercury	0.12	4
ICP Metals		
Cadmium	1.4	10
Chromium	11.	200
Lead	13.	100

Table 8.9-1 [illegible]7 South Plants Dewatering with Cap Estimated Influent Concentratio[illegible]

Chemical Group / Compound	Estimated Influent Concentration (ug/l)	Target Effluent Concentration (ug/l)
Volatile Halogenated Organic Compounds (VHOs)		
1,2-Dichloroethane	0.57	10
1,1-Dichloroethylene	1.4	14
1,1,1-Trichloroethane	0.53	400
1,1,2-Trichloroethane	0.43	6
Carbon tetrachloride	5.8	10
Chlorobenzene	7.9	50
Chloroform	92.	30
Methylene chloride	4.4	10
Tetrachloroethylene	7.2	10
Trichloroethylene	4.5	10
Volatile Hydrocarbon Compounds (VHCs)		
Dicyclopentadiene	30.	92
Volatile Aromatic Organic Compounds (VAOs)		
Benzene	13000.	10
Ethylbenzene	1.2	1360
o-and p-Xylene	4.0	20000
Toluene	6.7	2000
Organosulfur Compounds, Mustard Agent Related (OSCMs)		
1,4-Oxathiane	0.91	320
Dithiane	3.2	36
Organosulfur Compounds, Herbicide Related (OSCHs)		
Chlorophenylmethyl sulfide	2.6	60
Chlorophenylmethyl sulfone	9.0	72
Chlorophenylmethyl sulfoxide	2.3	72
Organophosphorous Compounds, GB-Agent Related (OPHGBs)		
Diisopropylmethyl phosphonate	1.1	1200
Organophosphorus Compounds, Pesticide Related (OPHPs)		
Atrazine	0.82	8.06
Malathion	0.09	200
Dibromochloropropane (DBCP)		
Dibromochloropropane	1.4	0.40

Table 8.9-1 S[illegible] South Plants Dewatering with Cap Estimated Influent Concentrations

Chemical Group / Compound	Estimated Influent Concentration (ug/l)	Target Effluent Concentration (ug/l)
Semivolatile Halogenated Organic Compounds (SHOs)		
Hexachlorocylopentadiene	0.28	0.46
Organochlorine Pesticides (OCPs)		
Aldrin	0.09	0.10
Chlordane	0.07	4
Dichlorodiphenylethane (DDE)	0.01	0.11
Dichlorodiphenyltrichlorothane	0.03	0.20
Dieldrin	0.16	0.10
Endrin	0.08	0.40
Isodrin	0.03	0.12
Arsenic		
Arsenic	2.9	100
Mercury		
Mercury	0.17	4
ICP Metals		
Cadmium	1.8	10
Chromium	9.8	200
Lead	16.	100

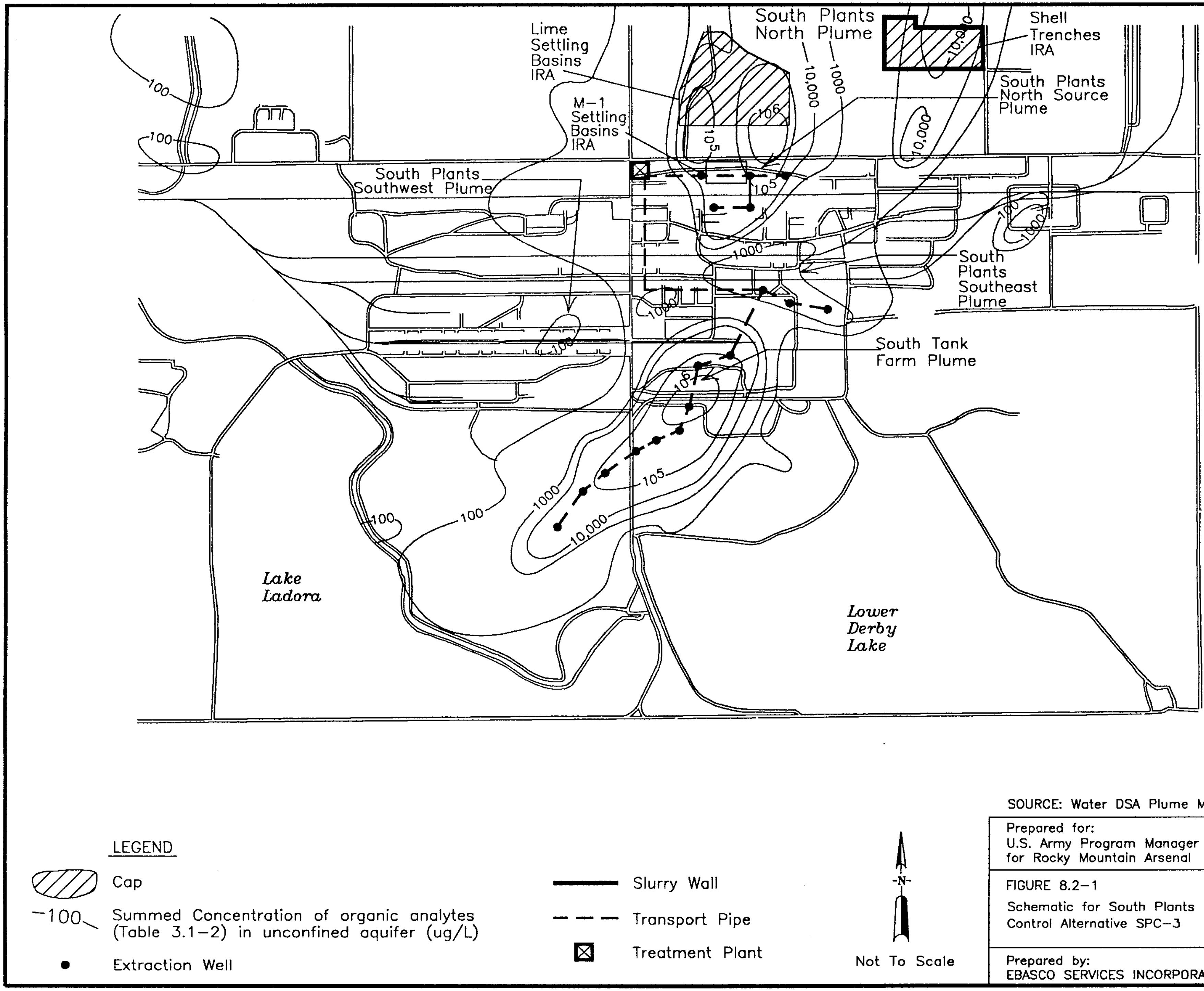


SOURCE: Water DSA Plume Map

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 8.1–1
Schematic for South Plants Plume Group
Control Alternative SPC–1

Prepared by:
EBASCO SERVICES INCORPORATED



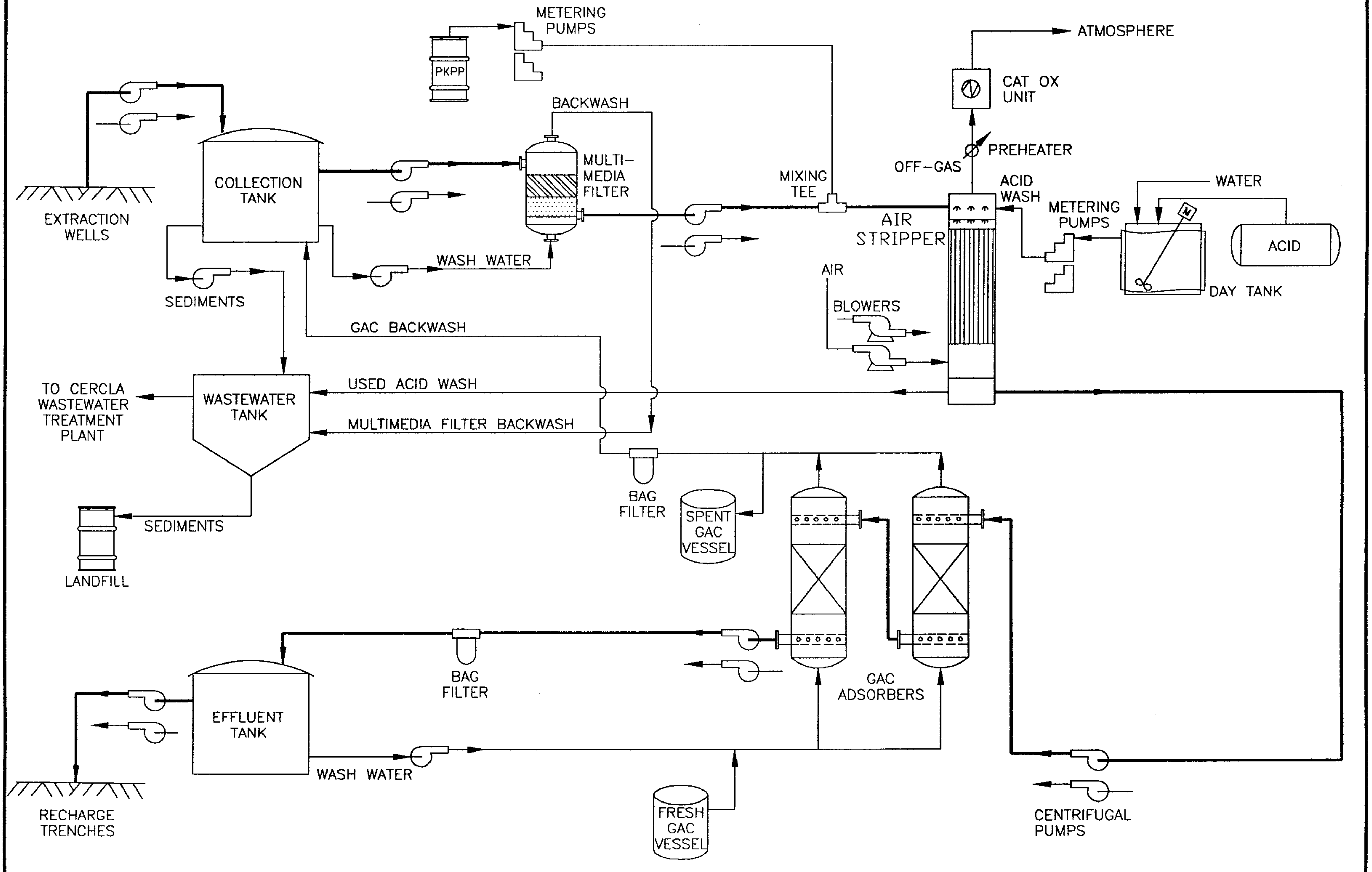
SOURCE: Water DSA Plume Map

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 8.2-1

Schematic for South Plants Plume Group Control Alternative SPC-3

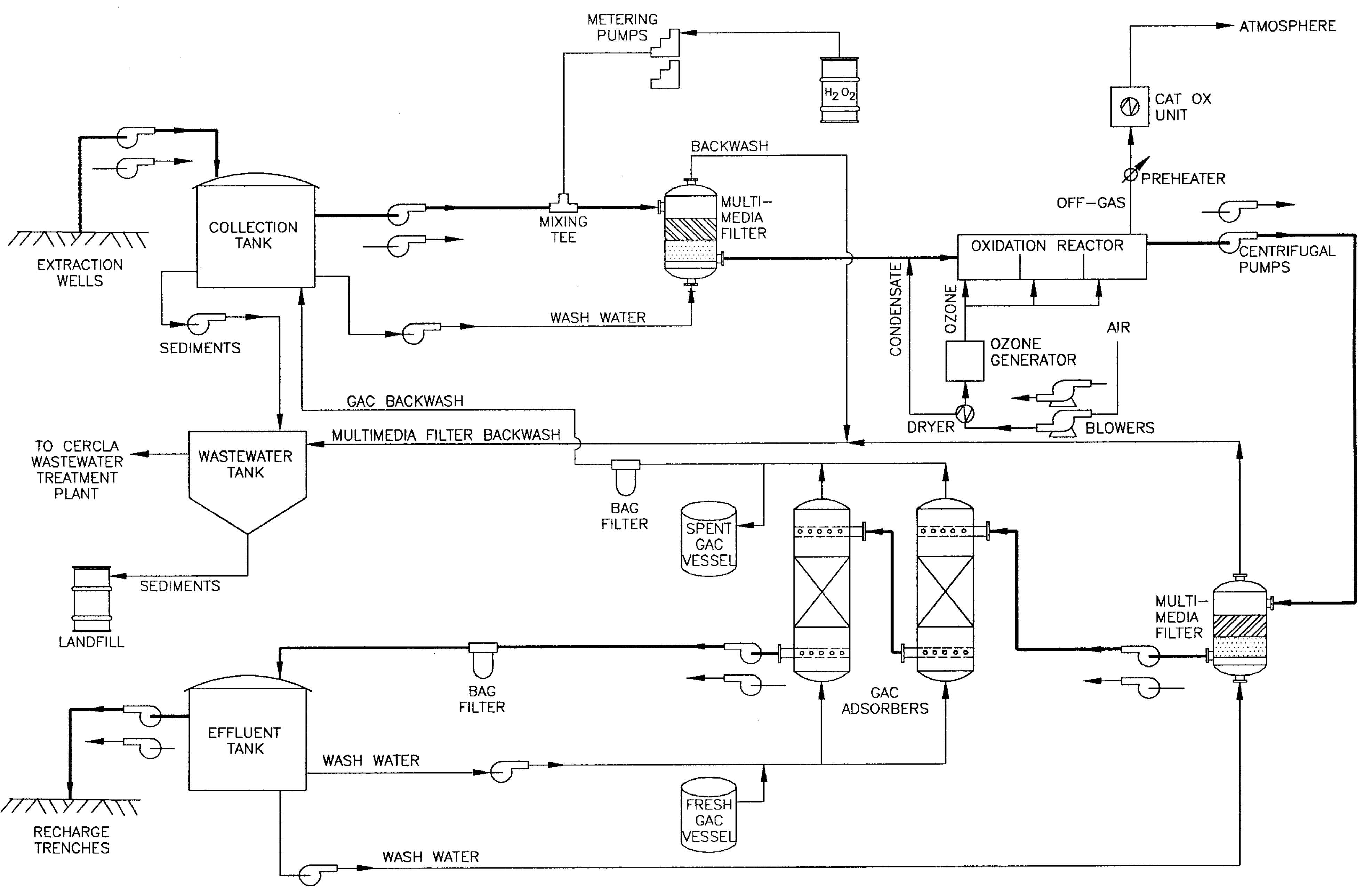
Prepared by:
EBASCO SERVICES INCORPORATED



Prepared for:
Office for the Program Manager
for Rocky Mountain Arsenal

FIGURE 8.2-2
Process Flow Diagram
Treatment Alternative SPT-2,
Air Stripping/GAC Adsorption

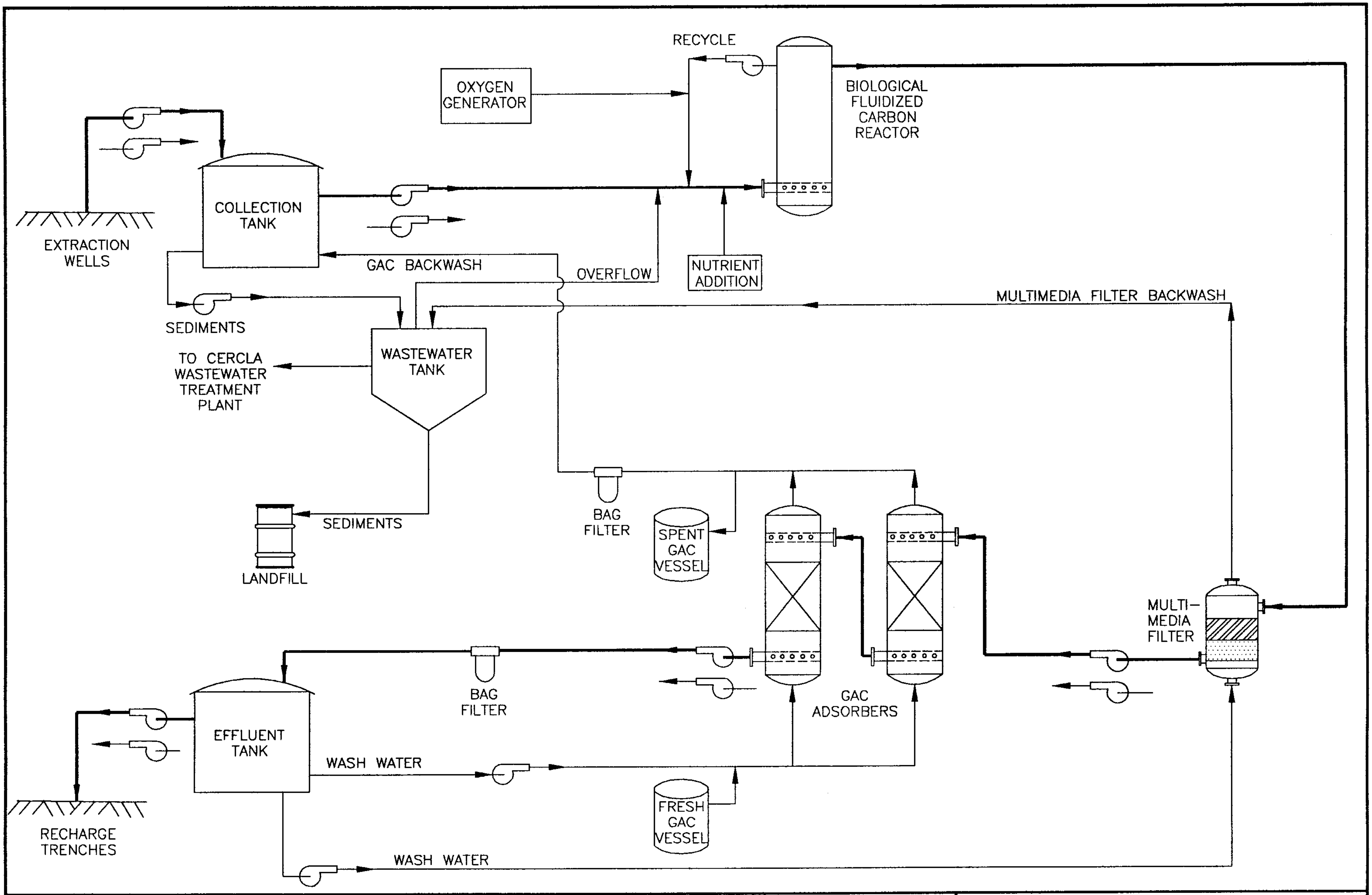
Prepared by:
Ebasco Services Incorporated



Prepared for:
Office for the Program Manager
for Rocky Mountain Arsenal

FIGURE 8.3-1
Process Flow Diagram
Treatment Alternative SPT-3,
Ozone/H_2O_2 Oxidation/GAC Adsoprtion

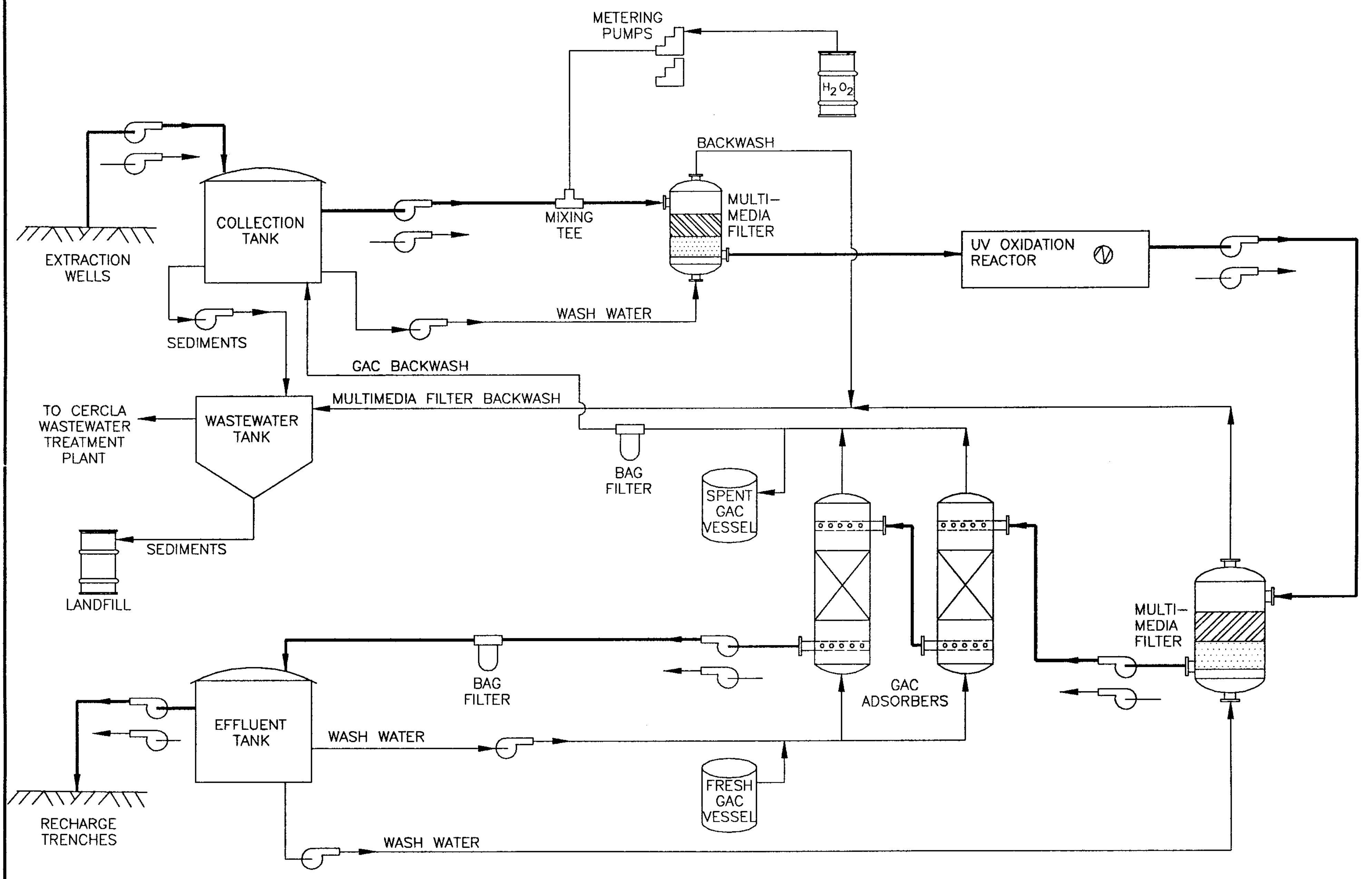
Prepared by:
Ebasco Services Incorporated



Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 8.4-1
Process Flow Diagram
Treatment Alternative SPT-4,
Direct Biological Treatment/GAC Adsorption

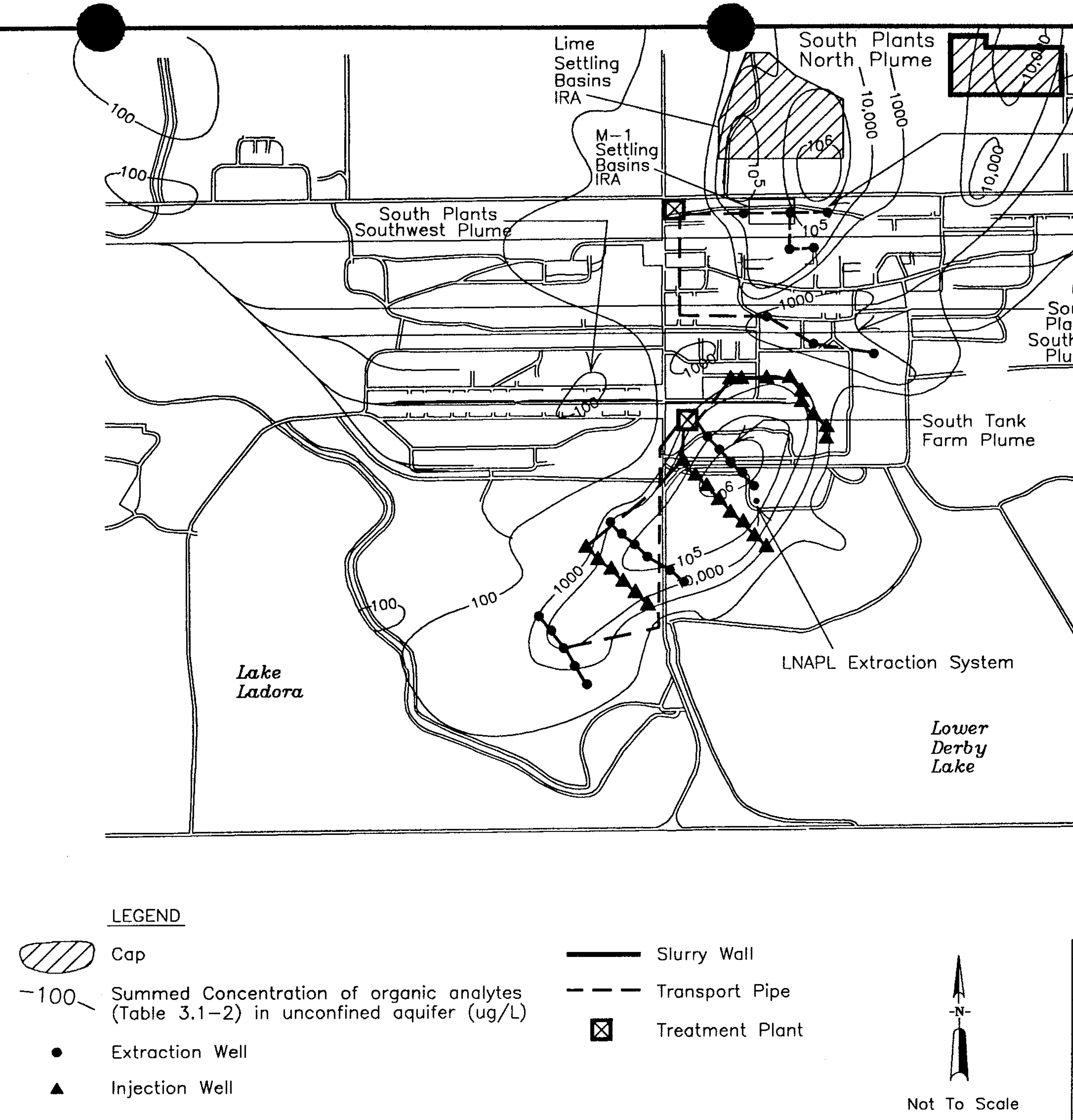
Prepared by:
Ebasco Services Incorporated



Prepared for:
Office for the Program Manager
for Rocky Mountain Arsenal

FIGURE 8.5-1
Process Flow Diagram
Treatment Alternative SPT-3 (with SPT-4)
UV/H_2O_2 Oxidation/GAC Adsorption

Prepared by:
Ebasco Services Incorporated

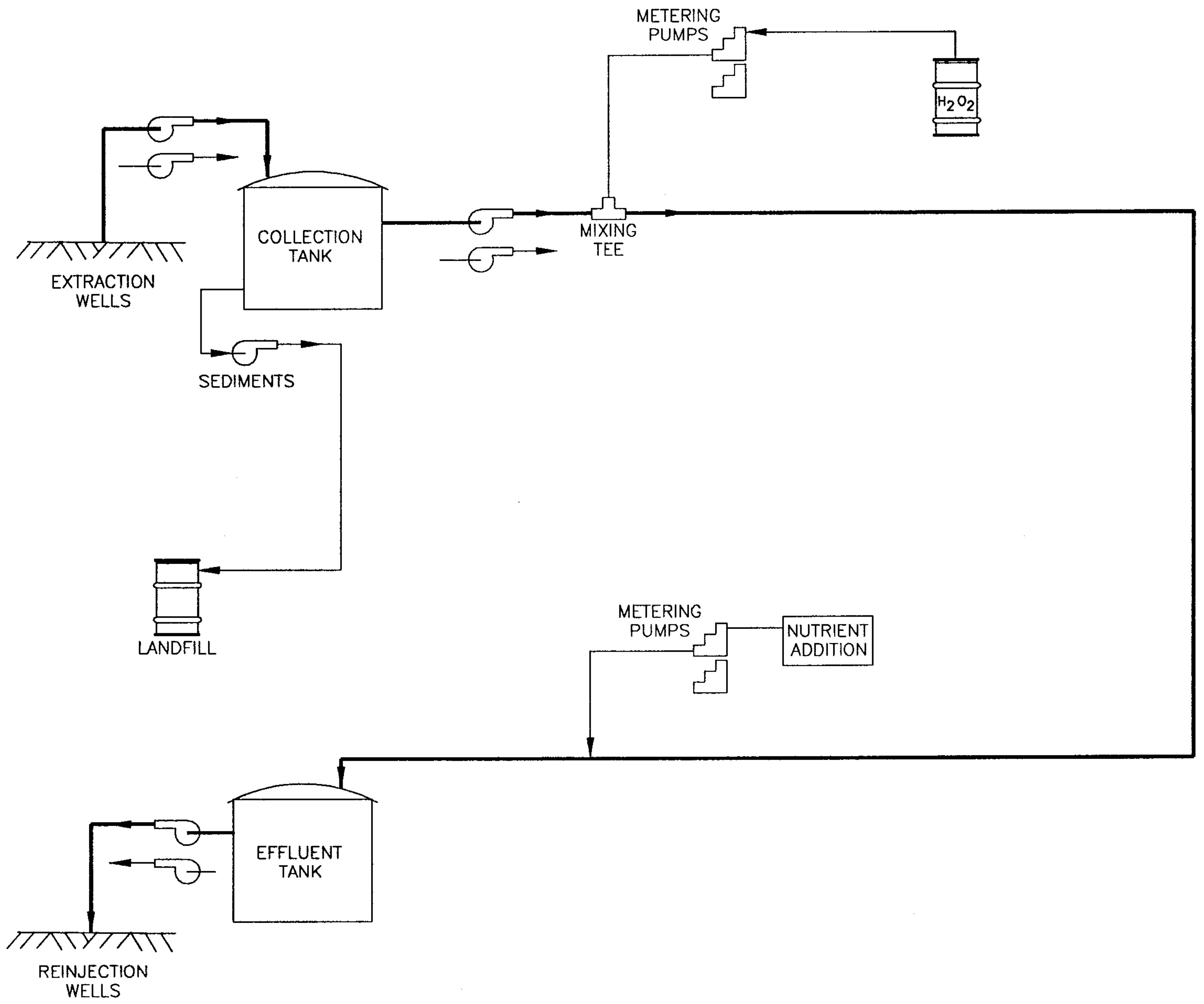


SOURCE: Water DSA Plume Map

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 8.6–1
Schematic for South Plants Plume Group
Control Alternative SPC–5

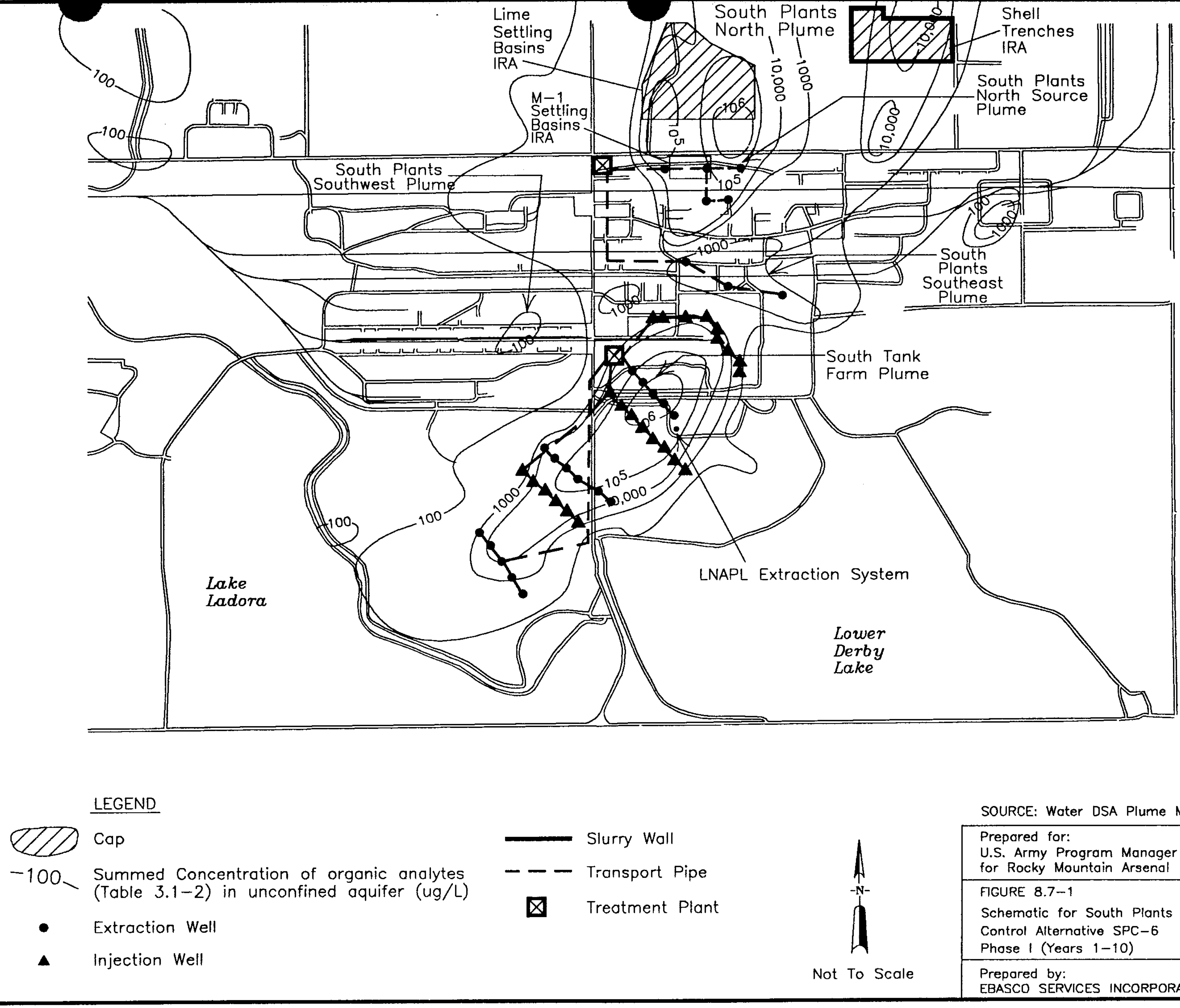
Prepared by:
EBASCO SERVICES INCORPORATED



Prepared for:
Office for the Program Manager
for Rocky Mountain Arsenal

FIGURE 8.6-2
Process Flow Diagram
Treatment Alternative SPT-5,
In Situ Biodegradation

Prepared by:
Ebasco Services Incorporated

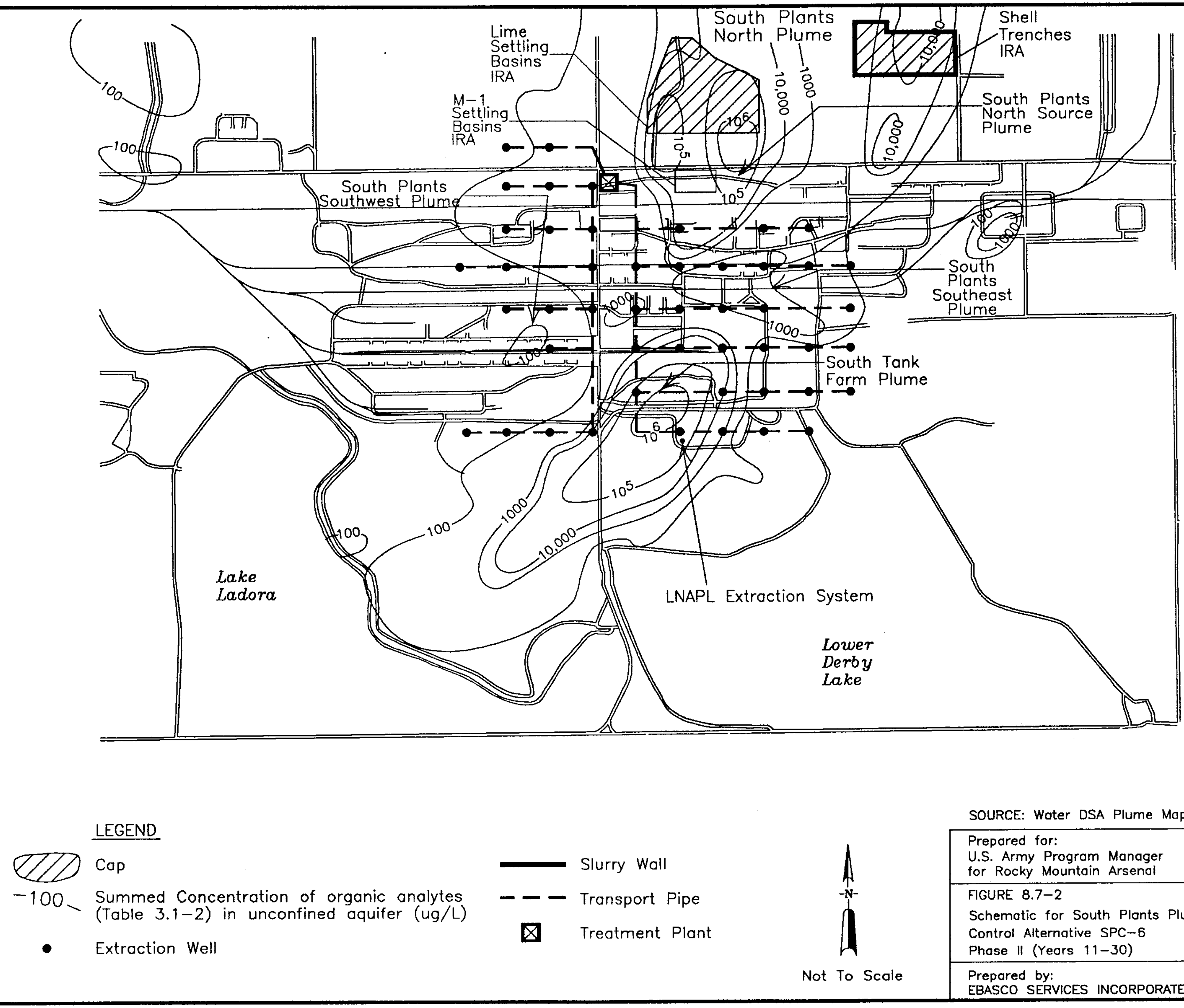


SOURCE: Water DSA Plume Map

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 8.7-1
Schematic for South Plants Plume Group
Control Alternative SPC-6
Phase I (Years 1-10)

Prepared by:
EBASCO SERVICES INCORPORATED

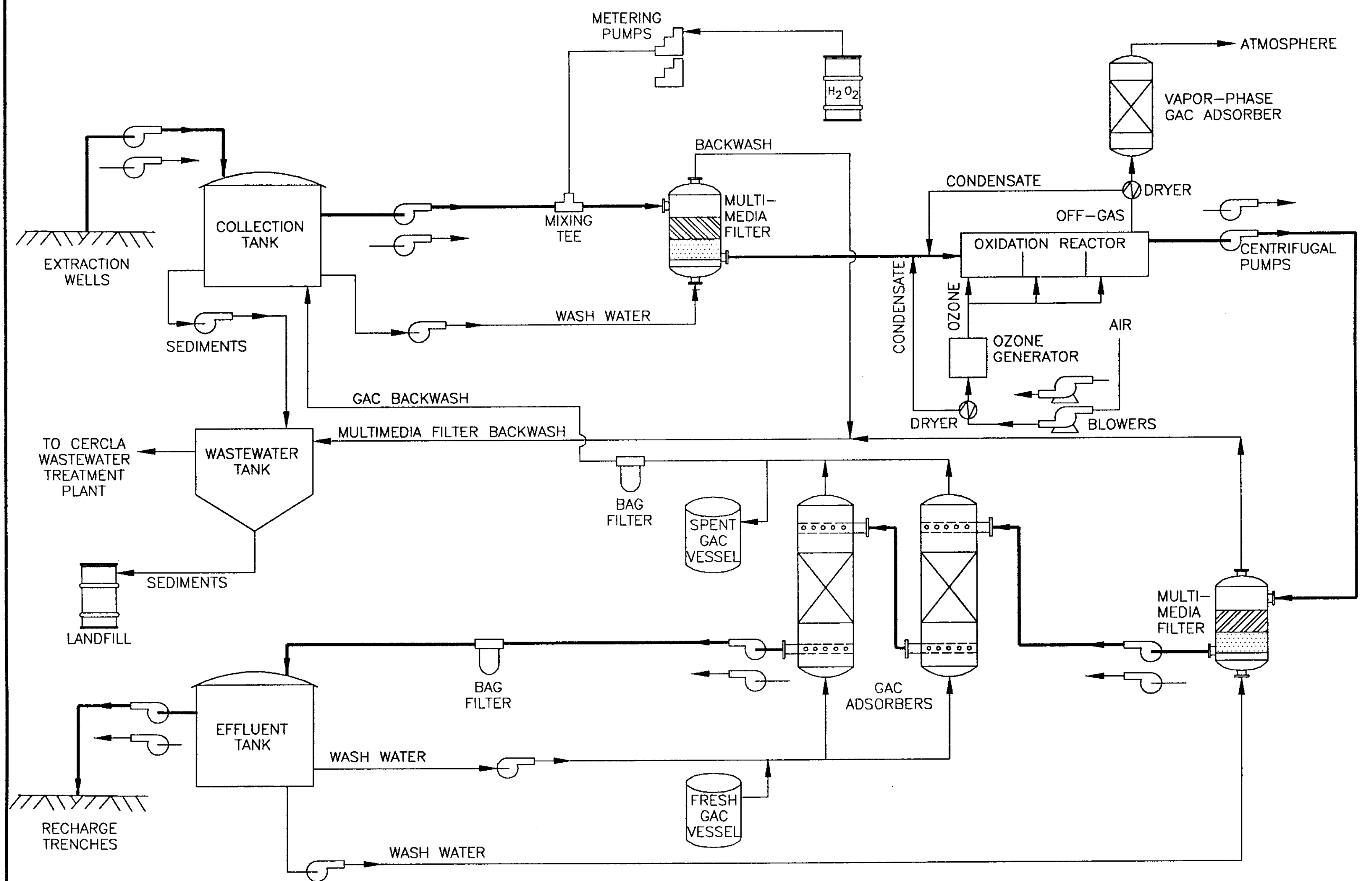


SOURCE: Water DSA Plume Map

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 8.7-2
Schematic for South Plants Plume Group
Control Alternative SPC-6
Phase II (Years 11-30)

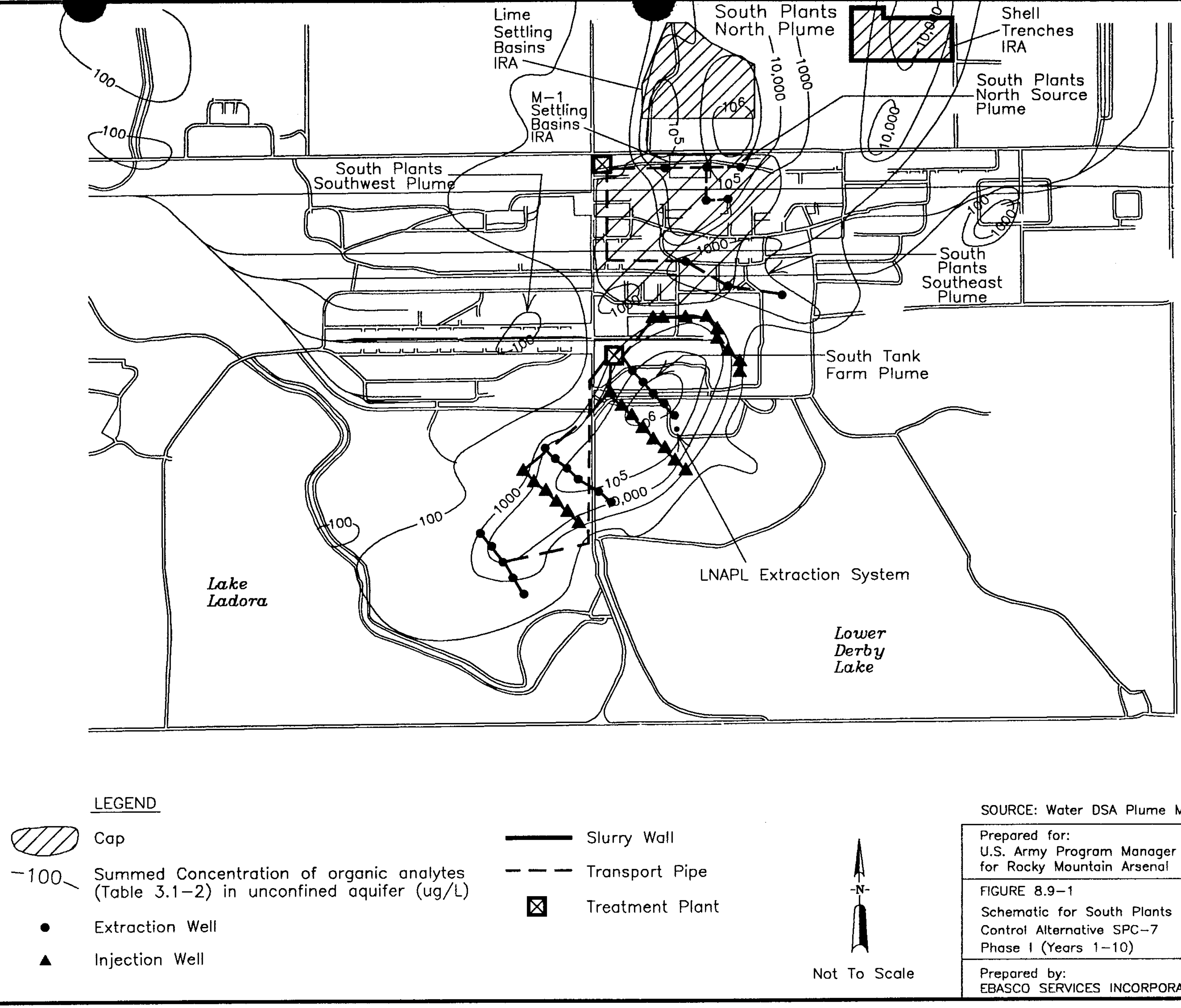
Prepared by:
EBASCO SERVICES INCORPORATED



Prepared for:
Office for the Program Manager
for Rocky Mountain Arsenal

FIGURE 8.8-1
Process Flow Diagram
Treatment Alternative SPT-3 (SPC-6 or SPC-7)
Ozone/H_2O_2 Oxidation/GAC Adsorption

Prepared by:
Ebasco Services Incorporated

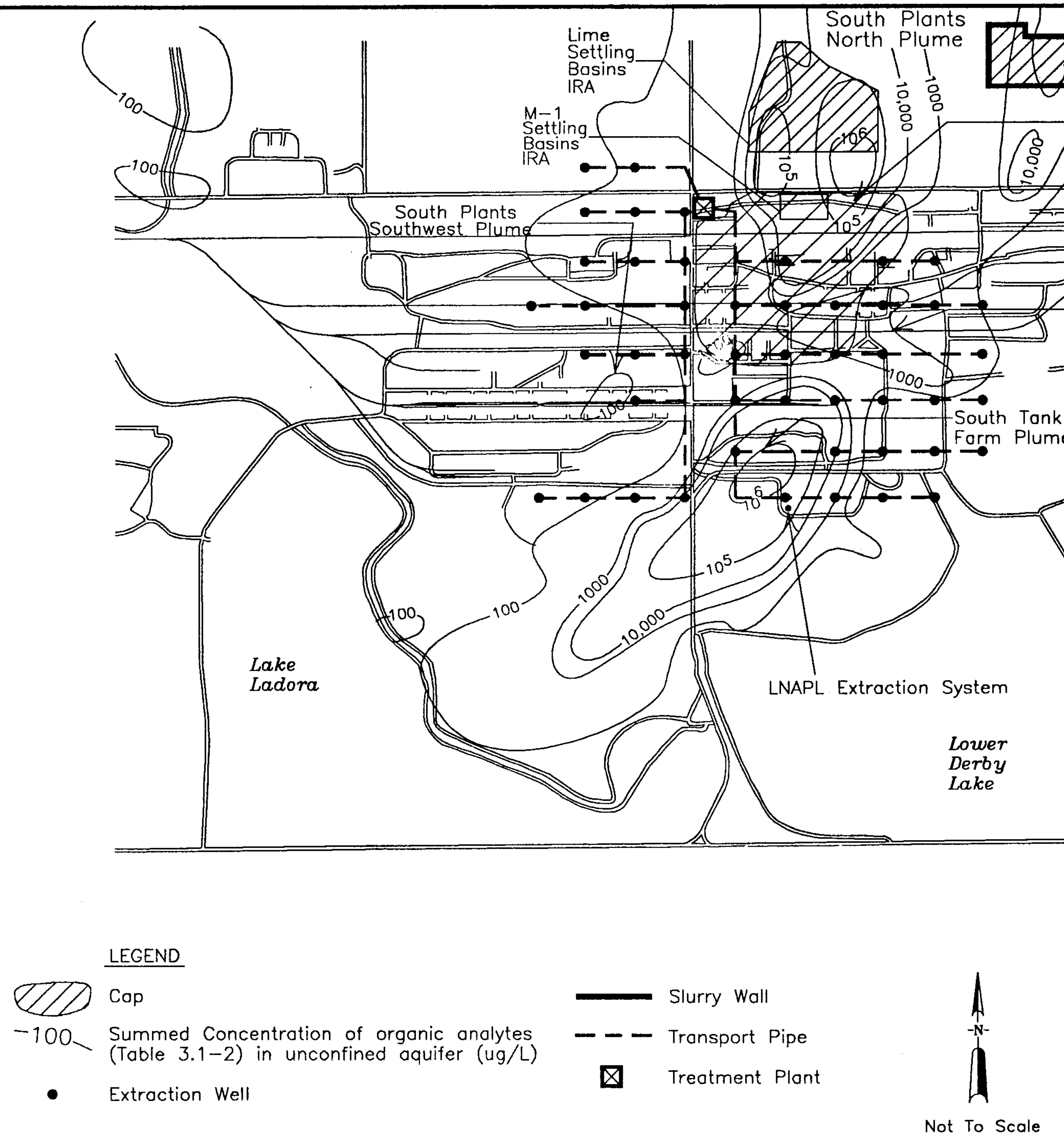


SOURCE: Water DSA Plume Map

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 8.9-1
Schematic for South Plants Plume Group
Control Alternative SPC-7
Phase I (Years 1-10)

Prepared by:
EBASCO SERVICES INCORPORATED



SOURCE: Water DSA Plume Map

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 8.9-2
Schematic for South Plants Plume Group
Control Alternative SPC-7
Phase II (Years 11-30)

Prepared by:
EBASCO SERVICES INCORPORATED

9.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

Based upon the evaluation of the individual alternatives presented in Sections 4 through 8, the alternatives are compared in this section with regard to how well they meet the EPA evaluation criteria. While the threshold criteria (overall protection of human health and the environment and compliance with ARARs) must be met or the ARARs must be waived, the alternatives' achievement of the balancing criteria provides the comparison necessary to select the preferred alternative. These five criteria (long-term effectiveness and permanence, reduction of TMV, short-term effectiveness, implementability, and cost), although equally weighted in guidance, vary in importance based on a number of plume-specific factors. For example, selection of a preferred alternative for the North Boundary Plume Group may be more focused on long-term effectiveness (since off-post PRGs must be met at the boundary) than one selected for the South Plants Plume Group, which may focus more heavily on reduction of TMV and implementability. The rationale for selecting a preferred alternative may differ between plume groups.

The alternatives are compared and the preferred alternatives selected in the following sections. Table 9.0-1 summarizes the preferred alternatives selected for all five plume groups.

9.1 NORTHWEST BOUNDARY PLUME GROUP

Only two alternatives were considered for the Northwest Boundary Plume Group, NWC-1, the No Action alternative, which involves removal of existing systems, and NWC-2, the Continued Existing Action alternative, which involves continued operation of NWBCS.

9.1.1 Overall Protection of Human Health and the Environment

Alternative NWC-2 is protective of human health and the environment. Alternative NWC-1 is not protective of human health or the environment, and may actually lead to increased risk of exposure off post since the boundary containment system is discontinued.

9.1.2 Compliance with ARARs

Alternative NWC-2 is in compliance with all ARARs, while Alternative NWC-1 does not comply with chemical-specific ARARs or the FFA.

9.1.3 Long-Term Effectiveness and Permanence

Alternative NWC-2 reduces concentrations in plumes migrating off post to acceptable levels, and provides adequate controls so long as operation is maintained long term. Alternative NWC-1 increases potential for off-post exposure relative to Alternative NWC-2 since all existing controls are removed.

9.1.4 Reduction of TMV

Contaminants are irreversibly removed by GAC adsorption under Alternative NWC-2, which significantly reduces contaminant toxicity and volume. This extraction and treatment system also reduces contaminant mobility. Alternative NWC-1, on the other hand, is likely to result in increases in toxicity and volume of contaminated groundwater as well as an increase in contaminant migration across the RMA boundary since all controls are removed. Reduction in contaminant levels through natural attenuation is insignificant as compared to the reduction through treatment provided under Alternative NWC-2.

9.1.5 Short-Term Effectiveness

Alternative NWC-2 has minimal negative impact on the environment, workers, and surrounding community. The breaching of the slurry wall under Alternative NWC-1 could have some potential impact on workers, but no impact on the surrounding community. The discontinuation of treatment allows contamination to migrate off post, thereby increasing the risk to the community and environment. RAOs are achieved through Alternative NWC-2, but not through Alternative NWC-1.

9.1.6 Implementability

Alternative NWC-2 is technically and administratively feasible and easily implemented since it is already operational. Alternative NWC-1 is technically but not administratively feasible since it does not comply with the FFA.

9.1.7 Cost

There are no capital costs associated with Alternative NWC-2, while the capital cost of breaching the slurry wall in Alternative NWC-1 is $48,000. Annual O&M costs are significantly lower for Alternative NWC-1 ($37,500) than for Alternative NWC-2 ($1,270,000), and present worth costs are also lower for Alternative NWC-1. However, the costs under Alternative NWC-1 only cover destruction of the existing system and monitoring, while the higher cost in Alternative NWC-2 covers continued capture and treatment both to achieve RAOs as well as to continue monitoring.

9.1.8 Selection of Preferred Alternative

The comparative analysis of Alternatives NWC-1 and NWC-2 conducted in the previous sections show that Alternative NWC-2 satisfies all seven EPA evaluation criteria while Alternative NWC–1 does not. Alternative NWC-1 does not provide protection of human health and the environment, is not in compliance with ARARs, may increase potential for off-post exposure in the long term, may potentially lead to an increase in TMV, and is not administratively feasible since it does not comply with the FFA.

The preferred alternative for the Northwest Boundary Plume Group is consequently NWC-2 (Table 9.1-1).

9.2 WESTERN PLUME GROUP

Only two alternatives were considered for the Western Plume Group, WC-1, the No Action alternative, which involves removal of the existing system, and WC-2, the Continued Existing Action alternative, which involves continued operation of the ICS capture and treatment system and the Motor Pool Area and Rail Classification Yard IRA capture systems.

9.2.1 Overall Protection of Human Health and the Environment

Alternative WC-2 is protective of human health and the environment off post since potential exposure is reduced to acceptable levels through treatment at the boundary. The IRA capture systems are also protective of the on-post environment. Alternative WC-1 does not provide protection of human health or the environment since contamination is allowed to migrate freely off post.

9.2.2 Compliance with ARARs

Alternative WC-2 is in compliance with all ARARs, while Alternative WC-1 does not comply with chemical-specific ARARs or the FFA.

9.2.3 Long-Term Effectiveness and Permanence

Continued operation of ICS and the Motor Pool Area and Rail Classification Yard IRAs under Alternative WC-2 minimizes the potential for off-post exposure, while Alternative WC-1 results in a potential for off-post exposure since contaminants are allowed to migrate off post. The controls provided under Alternative WC-2 are adequate, but may require long-term maintenance. All existing controls are removed under Alternative WC-1.

9.2.4 Reduction of TMV

Alternative WC-2 provides for irreversible removal of contaminants through GAC treatment of water captured in the Motor Pool and Rail Classification Yard areas and at the boundary thereby causing significant reduction in contaminant TMV. Alternative WC-1 does not involve any action to reduce contaminant concentrations and may lead to an increase in contaminant TMV. Insignificant reductions of TMV may take place under Alternative WC-1 as a result of natural attenuation.

9.2.5 Short-Term Effectiveness

Alternative WC-2 has minimal negative impact on the environment, workers, and surrounding community since it is already operational, and the Alternative WC-1 has minimal negative impact

since actions taken are of short duration and easy to implement safely. Alternative WC-2 is not expected to have any additional impact on the environment, while Alternative WC-1 allows contamination to migrate off post. Alternative WC-2 achieves RAOs while Alternative WC-1 does not.

9.2.6 Implementability

Alternative WC-2 is technically and administratively feasible and is already operational. Alternative WC-1 is technically but not administratively feasible since it does not comply with the FFA.

9.2.7 Costs

There are no capital costs associated with any of these alternatives. The O&M costs of Alternative WC-1 are significantly lower than for Alternative WC-2 at $57,500 and $911,000, respectively. The same is true for the present worth costs at $920,000 for Alternative WC-1 and $14,500,000 for Alternative WC-2. However, Alternative WC-1 costs include monitoring only and does not provide adequate protection through existing systems as does Alternative WC-2.

9.2.8 Selection of Preferred Alternative

The comparative analysis of Alternatives WC-1 and WC-2 conducted above showed that Alternative WC-2 satisfies all seven EPA evaluation criteria while WC-1 does not. Alternative WC-1 does not provide protection of human health and the environment, is not in compliance with ARARs, may increase potential for off-post exposure in the long term, may potentially lead to an increase in TMV, and is not administratively feasible since it does not comply with the FFA.

The preferred alternative for the Western Plume Group is consequently WC-2 (Table 9.2-1).

9.3 NORTH BOUNDARY PLUME GROUP

In the following section, alternatives for the North Boundary Plume Group are compared with respect to the seven EPA evaluation criteria (see Executive Summary).

9.3.1 Overall Protection of Human Health and the Environment

Except for Alternative NC-1, the No Action alternative, all alternatives provide protection of human health and the environment. Human health and the environment are protected on post by FFA restrictions that limit the use of on-post groundwater. Protection off post is ensured for all alternatives except Alternative NC-1 by operation of the NBCS, which treats groundwater to RAOs as it leaves the RMA boundary.

Alternative NC-2 provides adequate protection of human health and the environment on post by continued operation of the NBCS and the Basin F Groundwater IRA. This activity is also included in all of the other alternatives except Alternative NC-1.

The added benefit to the on-post environment provided by additional groundwater capture and treatment as in Alternatives NC-3/NT-2 (extraction, GAC adsorption, reinjection), NC-3/NT-3 (extraction, air stripping, GAC adsorption, reinjection), and NC-3/NT-4 (extraction, oxidation, reinjection) is small. These alternatives use extraction wells to capture a relatively small volume of contaminated groundwater from the Basins C and F Plume where it is most concentrated and then treat it to meet PRGs.

Alternative NC-6, which involves installation of a cap over portions of Basins C and F, is also protective of the environment, but not as protective as the NC-3 alternatives. Installation of the cap reduces the mass of contaminants that may leach into the aquifer from the unsaturated zone by reducing recharge, but it does not remove the contamination from the groundwater to the same levels as do the NC-3 alternatives.

9.3.2 Compliance with ARARs

All of the alternatives except Alternative NC-1 comply with action-, chemical-, and location-specific ARARs. Alternative NC-1 allows contamination to migrate off post, which does not comply with chemical-specific ARARs or the FFA.

9.3.3 Long-Term Effectiveness and Permanence

All alternatives except Alternative NC-1 provide long-term effectiveness off post because they operate until the influent concentrations are below PRGs and the groundwater treatment systems are no longer needed. Alternatives NC-3/NT-2, NC-3/NT-3, and NC-3/NT-4 have additional extraction and treatment systems on post that remove contaminant mass from the Basins C and F Plume before the plume reaches the boundary. By intercepting contaminants where the plume is most concentrated, the mass of contaminant removed is increased. However, the effectiveness is only slightly higher than for Alternative NC-2. If the plume is allowed to migrate naturally to the north boundary, it becomes more diluted and dispersed through Sections 23 and 24 and requires long-term treatment of a large volume of water. The mass of contaminants removed by the NBCS is decreased due to sorption of contaminants to the aquifer materials. These alternatives do not provide additional extraction and treatment of the North Plants Plume, which is treated at the NBCS.

Alternative NC-2 is effective for interception of the relatively small rate of groundwater flow through a limited extent of saturated alluvium. The operation of the Basin F IRA provides partial control of contaminated groundwater contamination movement near the source.

Alternative NC-6 is less effective in the long term although installation of a cap reduces recharge and leaching of contaminants, because it does not remove and treat contaminants from the most contaminated groundwater as in the NC-3 alternatives. The cap reduces recharge rates, which reduces the contaminant mass leaching into the groundwater from these soils. These contaminants remain in the vadose zone, and could potentially leach back into groundwater over time if the cap deteriorates.

Alternative NC-1 is not effective in the long term because contaminants currently in the aquifer, or those that may leach into the aquifer, are not removed. These contaminants remain in the aquifer and move off post where the potential for human exposure through drinking water wells is high.

9.3.4 Reduction of TMV

Treatment with GAC at the NBCS is the primary treatment method for all alternatives except Alternative NC-1. The NBCS extracts and treats up to 300 gpm for each of these alternatives and effectively reduces the contaminant TMV by transferring contaminants from the extracted groundwater to the GAC. Alternative NC-3/NT-4 pumps water to the Basin A Neck IRA for treatment in a modified system.

Alternative NC-2 relies exclusively on the NBCS to reduce contaminant TMV in the North Plants and Basins C and F Plumes. It is effective for the partial control of contaminant migration through the alluvium near Basin F.

The three alternatives that use the NC-3 control system provide some additional reduction of contaminant TMV through extraction and treatment of up to 6 gpm, some of which comes from the Basins C and F Plume, compared to Alternative NC-2. Alternative NC-3/NT-2 uses GAC, Alternative NC-3/NT-3 uses air stripping followed by GAC, and Alternative NC-3/NT-4 uses oxidation followed by GAC to treat this stream. Alternative NC-3/NT-4 uses the least amount of carbon because a large fraction of the contaminants are destroyed in the oxidation reactor. Alternative NC-3/NT-3 has the next highest carbon consumption, and Alternative NC-3/NT-2 uses the most carbon.

Alternative NC-6 reduces contaminant mobility and volume by restricting groundwater flow and recharge. No treatment other than the NBCS takes place under this alternative. This alternative, through the NBCS, provides for removal of contaminant mass from the environment. This is a

less effective method for TMV reduction than the NC-3 alternatives since contamination is allowed to disperse from the source area, making it more costly to capture and treat.

Alternative NC-1 provides reduction of TMV only through natural attenuation. Contamination in the aquifer and vadose zone decreases very slowly in the environment and continues to migrate off post.

9.3.5 Short-Term Effectiveness

The short-term effectiveness of Alternatives NC-2, NC-3/NT-2, NC-3/NT-3, and NC-3/NT-4 is roughly equivalent. All of these alternatives have minimal impact on the environment and surrounding community during construction, and none pose special threats to workers. These alternatives also achieve RAOs at the boundary through operation of the NBCS, and all are estimated to operate for at least 100 years.

Alternative NC-6 is slightly less effective in the short term than the other alternatives because constructing a clay/soil cap may cause more of an impact on the workers and community. Dust suppression may be required during construction to minimize impacts on the surrounding community. This alternative also meets RAOs at the boundary and is expected to operate for more than 100 years.

Alternative NC-1 is the least effective in the short term because the environment is not adequately protected. Although natural attenuation is ongoing, RAOs are not achieved at the boundary and contamination is free to migrate off post.

9.3.6 Implementability

All of the alternatives are technically feasible in that all involve demonstrated, available technologies (well installation, cap installation, GAC adsorption, and air stripping) already in use at RMA. Alternative NC-3/NT-4 is the only alternative that includes an innovative technology (oxidation) that requires more oversight and additional operator training than the other alternatives.

All of the alternatives are administratively feasible, with the exception of Alternative NC-1. This alternative is not in compliance with the FFA because it allows contaminants to migrate off post.

9.3.7 Cost

Alternative NC-1 has a present worth cost of $1,360,000, which is significantly lower than any of the other alternatives. This is followed by Alternative NC-2 at $41,200,000, which is the only alternative to have a zero capital cost. Capital costs, annual O&M costs, and present worth costs each increase for Alternatives NC-3/NT-2, NC-3/NT-3, and NC-3/NT-4, respectively. The capital cost for Alternative NC-6 is one order of magnitude higher than for the other alternatives at $49,600,000, although the annual O&M costs are comparable to the other alternatives. Alternative NC-6 also has the highest present worth cost at $90,900,000.

9.3.8 Selection of Preferred Alternative

The preferred alternative for the North Boundary Plume Group is Alternative NC-2, Continued Existing Action. This alternative is preferred because it provides protection of human health off post through operation of the NBCS and protection of the environment on post through continued operation of the Basin F Groundwater IRA. This alternative was selected because the benefit of additional extraction/treatment on post is small. The existing extraction system reduces migration of contaminants through the alluvium north of Basin F. In addition, this alternative provides both short- and long-term protection and is easily implementable (Table 9.3-1).

9.4 BASIN A PLUME GROUP

In the following section, the five alternatives evaluated for the Basin A Plume Group are compared with respect to the seven EPA evaluation criteria (see Executive Summary). The five alternatives are the following: (no action) AC-1, (continued existing action) AC-2, (mass reduction, stripping/GAC adsorption) AC-3/AT-2, (mass reduction stripping, oxidation, GAC adsorption) AC-3/AT-4, and (capping) AC-7.

9.4.1 Overall Protection of Human Health and the Environment

All of the alternatives provide protection of human health and the environment. The provisions of the FFA require that groundwater on post not be used as potable water. The boundary systems ensure that all water that leaves the RMA boundary complies with PRGs.

Alternative AC-1, the No Action alternative, includes the discontinuation of the Basin A Neck IRA, which allows for increased migration of contaminants toward the boundary systems. Alternatives AC-2 and AC-7 rely on the operation of the Basin A Neck IRA for intercepting contaminant migration in the Basin A Plume Group. Alternatives AC-3/AT-2 and AC-3/AT-4 provide additional protection of the environment by reducing contaminant mass in the groundwater near the sources.

9.4.2 Compliance with ARARs

All of the alternatives developed for the Basin A Plume Group comply with action-, chemical-, and location-specific ARARs.

9.4.3 Long-Term Effectiveness and Permanence

Alternatives AC-3/AT-2 and AC-3/AT-4 afford the highest degrees of long-term effectiveness and permanence because they provide for mass removal and treatment near the sources of the contamination, reducing migration of the contaminants. These alternatives reduce the magnitude of residual risks by permanently removing contamination from the environment, and they lower the groundwater levels in the Basin A Plume Group, further reducing the potential for migration. These alternatives differ only in the treatment of the groundwater once it is removed.

As part of a preferred alternative for the soils medium, a cap is constructed covering the Basin A area. Alternative AC-7 includes this cap, which reduces residual risks by immobilizing the contaminants.

Except for Alternative AC-1, all of the alternatives include operation of the Basin A Neck IRA, which captures and treats contaminants as they migrate through the Basin A Neck area. This intercept and treatment system reduces contaminant migration and loading on the boundary systems. Although the Basin A Neck IRA is effective at capturing the groundwater migrating through the Basin A Neck, it relies on natural groundwater flow to move the contaminants to the extraction wells for treatment as they migrate. A mass removal system, in comparison, removes the contaminants close to the source and reduces the contaminant mass that is mobile.

Migration of contaminants is not controlled or impacted by Alternative AC-1. This alternative allows the migration of contaminants to the RMA boundaries, increasing the loading on the boundary systems.

9.4.4 Reduction of TMV

Alternatives AC-3/AT-2 and AC-3/AT-4 provide for a reduction of TMV through removal and treatment near the source of the contamination. Alternative AC-3/AT-2 employs air stripping to volatilize organics, followed by GAC adsorption to remove remaining compounds that do not volatilize. Alternative AC-3/AT-4 involves oxidation to destroy the majority of the contaminants, air stripping to remove the volatiles, and GAC adsorption to remove the residual contaminants. Vapor-phase emissions in both of these treatment systems are treated by catalytic oxidation. Both treatment systems are effective at treating the contaminants to the TECs, but Alternative AC-3/AT-4 consumes less carbon than Alternative AC-3/AT-2. These systems treat 10 gpm each from the Basin A, South Plants North, and Section 36 Bedrock Ridge Plumes.

From a control perspective, Alternative AC-3 removes the contaminant mass from the plume centers. (The Basin A Neck IRA intercept system was also assumed to be operating throughout the life of this alternative.) The mass reduction phase is followed by capping. The reduction of contaminant TMV for the capping phase is the same as Alternative AC-7 since the second phase of Alternative AC-3 is identical to Alternative AC-7.

Alternative AC-7 reduces contaminant mobility and plume volume by restricting groundwater flow and recharge due to construction of a soil cap. No treatment other than the Basin A Neck IRA takes place under this alternative. Under this alternative, contaminated groundwater in the Basin A Plume Group migrates to the Basin A Neck IRA. As groundwater migrates, the water table is lowered, trapping the contaminants that are sorbed to the soil in the vadose zone. Because the groundwater is no longer in contact with these contaminants, contaminant mobility is reduced. This is a less effective method for reducing TMV than Alternatives AC-3/AT-2 and AC-3/AT-4 since the contaminant mass is allowed to disperse, making it slower and potentially more costly to capture and treat.

Alternative AC-2 includes the continued operation of the Basin A Neck IRA, which captures and treats contaminants moving out of the Basin A Plume Group area.

Alternative AC-1 does not include any treatment. Contaminants are free to migrate at their current concentrations. Contaminant TMV is reduced over time by natural attenuation.

With the exception of Alternative AC-1, all of the alternatives include a reduction of TMV by the Basin A Neck IRA through GAC adsorption. This system treats up to 15 gpm through an interception system.

9.4.5 Short-Term Effectiveness

Except for Alternative AC-1, all of the alternatives provide short-term effectiveness. There are minimal impacts on the environment, workers, and the community. RAOs are achieved for all of the evaluated alternatives.

Alternative AC-2 requires no additional construction or handling and has the smallest impact on short-term effectiveness. Alternatives AC-3/AT-2 and AC-3/AT-4 involve air stripping. During washing of air stripper packing, proper acid-handling techniques must be observed. Alternative AC-3/AT-4 also requires the generation of ozone for the oxidation process. Ozone, a toxic gas,

must be constantly monitored. Workers and GAC vendors are informed of the contaminants and the need for PPE as necessary. During construction of these systems, proper dust control measures are enacted, as are measures to control dermal exposure. Both of these alternatives require operation of mass reduction systems for 10 years followed by installation of a cap, which is discussed under Alternative AC-7.

Alternative AC-7 requires dust control techniques to minimize dust dispersion during cap construction. As with the other alternatives, on-post workers are required to wear the appropriate PPE.

It is estimated that the Basin A Neck IRA, which is included in all alternatives except AC-1, is to be operated for more than 100 years. This system requires the replacement of contaminated GAC, which requires health and safety measures for operators and the GAC vendors.

Alternative AC-1 can be implemented with no worker exposure and community effects during the remedial action.

9.4.6 Implementability

Alternative AC-2 is already in operation and is therefore the easiest to implement. No additional considerations are required in the implementation of this alternative.

Alternatives AC-3/AT-2 and AC-7 involve construction of systems that are similar to existing systems at RMA and that do not require any additional training for workers or treatability evaluations. The equipment and technologies are known to be reliable and commercially available. Alternative AC-7 is identical to the second phase of Alternative AC-3.

Alternative AC-3/AT-4 contains much of the same equipment as Alternative AC-3/AT-2, which is readily available. However, the advanced oxidation process is innovative and it requires additional treatability testing to ensure its implementability for this application.

Alternative AC-1 is easily implemented as it would only require the shut down of an existing treatment system, the Basin A Neck IRA. However, if the IRA is shut down, justification as to why it is not incorporated in the final response action will be required.

9.4.7 Costs

Alternative AC-2 has no capital costs, but higher O&M and present worth costs than Alternative AC-1. If Alternative AC-1 is evaluated for cost effectiveness, the present worth cost is excessive ($1,530,000), given that there is no treatment involved. Of the remaining alternatives, Alternative AC-7 has no capital cost because the cap costs are associated with the soils alternative. Therefore, the real cost of Alternative AC-7 would be much higher if the capping cost were included. The annual O&M and present worth costs of Alternative AC-7 are $1,100,000 and $17,400,000, respectively. Alternatives AC-3/AT-2 and AC-3/AT-4 have almost identical present worth costs $30,300,000 and $30,200,000, respectively and differ primarily in first-year capital costs.

9.4.8 Selection of Preferred Alternative

The comparative analysis of the Basin A Plume Group conducted above showed that Alternatives AC-3/AT-2 and AC-3/AT-4 equally meet the seven EPA evaluation criteria. The preferred alternative for the Basin A Plume Group is Alternative AC-3/AT-2, which involves mass reduction combined with air stripping and GAC adsorption. This alternative (as well as Alternative AC-3/AT-4) provides for the greatest protection of human health and the environment, but Alternative AC-3/AT-2 is the most cost effective and uses the most easily implemented technologies of the two. The effectiveness of this alternative is greatly enhanced by the addition of the soil/clay cap as part of the soils remediation, which reduces groundwater recharge and contaminant leaching.

The preferred alternative for the Basin A Plume Group is, consequently, Alternative AC-3/AT-2 (Table 9.4-1).

9.5 SOUTH PLANTS PLUME GROUP

In the following section, nine alternatives for the South Plants Plume Group are compared with respect to each of the seven EPA evaluation criteria detailed in the Executive Summary. The mass reduction alternative (SPC-3) is combined with air stripping and GAC adsorption (SPT-2) or oxidation and GAC adsorption (SPT-3) for all plumes, and for the North Source and Southeast Plumes only when the South Tank Farm Plume is treated with direct biological treatment and GAC adsorption (SPT-4). Some of the South Plants alternatives use a phased approach in which only the South Tank Farm Plume and a small fraction of the Southeast and South Plants North Source Plumes are treated during the first 10 years of operation followed by mass reduction (SPC-5), dewatering (SPC-6), or dewatering and capping (SPC-7). Alternative SPC-5 involves treatment by in situ biodegradation (SPT-5) in the first phase and air stripping and GAC adsorption (SPT-2) in the second phase. Alternative SPC-6 involves in situ biodegradation (SPT–5) in the first phase and air stripping and GAC adsorption (SPT-2) or oxidation and GAC adsorption (SPT-3) in the second phase. The only difference between Alternatives SPC-6 and SPC-7 is the cap.

9.5.1 Overall Protection of Human Health and the Environment

All of the alternatives retained for the South Plants Plume Group are protective of human health both on post and off post. Human health is protected off post by continued operation of the existing boundary systems and IRAs in other parts of RMA and on post by the FFA.

The environment on post is most protected by alternatives that treat the greatest volume of contaminated water over the longest period of time. These are Alternatives SPC-6 and SPC-7, which extract contaminated groundwater using a mass reduction approach for the first 10 years of operation, and then dewater the South Plants groundwater mound for an estimated 100 years. These controls protect the environment by removing contaminant mass in the most concentrated part of the plumes during the first 10 years of operation. Once mass reduction is complete, the mound dewatering grid ensures hydraulic gradient control and prevents the rise in hydraulic head in the mound area. A rise in hydraulic head could result in migration of contaminants to the west

and northwest, as well as toward the south lakes. Some residual contamination in the aquifer not removed by mass reduction is also removed by the South Plants dewatering grid. The SPC-7 alternatives are the same as the SPC-6 alternatives, but with the addition of a cap over the South Plants Central Processing Area prior to dewatering. The cap prevents continued leaching of contaminants from soil to groundwater in the South Plants Central Processing Area. Groundwater is captured and treated during the dewatering phase as in Alternative SPC-6. Because the cap limits contaminant leaching, the SPC-7 alternatives are the most protective of the environment.

The treatment options associated with these control alternatives are air stripping followed by GAC adsorption during the mass reduction phase, and then either air stripping/GAC or oxidation/GAC during the dewatering phase. In situ biodegradation of the South Tank Farm Plume is also included in all of these alternatives. SPC-6 and SPC-7 alternatives are designed to be effective in treating extracted contaminants and have the same in situ treatment system; therefore, the alternatives are best differentiated by how they achieve control of the groundwater.

The third most protective alternative is Alternative SPC-5/SPT-2/SPT-5, which employs mass reduction in the South Plants North Source Plume and South Plants Southeast Plume for 10 years, but does not include dewatering of the South Plants groundwater mound. This alternative also includes in situ biodegradation in the South Tank Farm Plume. It is similar to Alternative SPC–6/SPT–2/SPT–5, but does not include the second phase dewatering step. In situ biodegradation of the South Tank Farm Plume produces slightly less waste from the treatment process than direct biological treatment and makes this alternative slightly more favorable than the remaining alternatives, which do not include in situ treatment.

The remaining alternatives that include active treatment of the South Plants Plume Group are the SPC-3 alternatives, which consist of groundwater extraction in a mass reduction configuration followed by treatment and reinjection. These alternatives are less effective than the SPC-6 and SPC-7 alternatives because they do not include an extended dewatering phase that also allows removal and treatment of residual contamination. The SPC-3 alternatives are only slightly less

effective than Alternative SPC-5/SPT-2/SPT-5, which differs from the SPC-3 alternatives in that it includes in situ biodegradation of the South Tank Farm Plume rather than direct treatment of that plume. The in situ treatment is slightly more effective in the short term than the direct treatment because it produces less waste, although the degree to which contaminant TMV is reduced is less certain.

The SPC-3 alternatives include four options for direct treatment: air stripping/GAC, oxidation/GAC, air stripping/GAC with direct biological treatment of the South Tank Farm Plume, or oxidation/GAC with direct biological treatment of the South Tank Farm Plume. All of these treatment systems ensure the permanent removal of contaminants from the extracted water; therefore, all of the SPC-3 alternatives are equally effective with respect to their protection of the environment.

Alternative SPC-1 is the least protective of the environment because contaminants are left in the aquifer. It is anticipated that some of this contamination is removed in existing treatment systems at RMA (e.g., the boundary systems and the Basin A Neck and Basin F Groundwater IRAs). Leaving contamination in the aquifer under South Plants increases the potential that the contamination will migrate into deeper aquifers where it will be more difficult to capture and treat.

9.5.2 Compliance with ARARs

All of the alternatives developed for the South Plants Plume Group comply with action-, location-, and chemical-specific ARARs.

9.5.3 Long-Term Effectiveness and Permanence

The long-term effectiveness of the alternatives developed for South Plants is primarily dependent on their means of controlling groundwater movement through extraction, injection, and containment. The alternatives that provide the greatest degree of long-term effectiveness are Alternatives SPC-7/SPT-2/SPT-5 and SPC-7/SPT-3/SPT-5. These include mass reduction of the

South Plants North Source and South Plants Southeast Plumes, along with in situ biodegradation in the South Tank Farm Plume, for the first 10 years (while a cap is being installed over the South Plants Central Processing Area). After the cap is installed, the groundwater mound in South Plants is dewatered for up to 100 years. This approach removes contaminants near the source during the mass reduction phase, and reduces the potential for long-term contaminant migration through dewatering and installation of the cap.

The treatment options for these alternatives are air stripping (with vapor-phase GAC treatment of the vapor emissions) followed by GAC adsorption plus in situ biodegradation of the South Tank Farm Plume (Alternative SPC-7/SPT-2/SPT-5) or ozone/hydrogen peroxide oxidation followed by GAC adsorption and in situ biodegradation (Alternative SPC-7/SPT-3/SPT-5). These technologies provide comparable long-term effectiveness because contaminants are irreversibly removed. Oxidation has an advantage in that the contaminants are destroyed in the oxidation unit. GAC treatment involves adsorption of the contaminants onto the carbon which is thermally regenerated off-post. Air stripping also involves transfer of contaminants from the water into the air stream, and then onto vapor-phase GAC, which is regenerated off post.

The next most effective alternatives are the SPC-6 alternatives, which are exactly the same as the SPC-7 alternatives, except that no cap is installed over the South Plants Central Processing Area. Alternatives SPC-6/SPT-2/SPT-5 and SPC-6/SPT-3/SPT-5 are slightly less effective than the SPC-7 alternatives because the cap in the SPC-7 alternatives reduces contaminant migration more effectively than does dewatering alone (as in the SPC-6 alternatives).

The remaining alternatives involve a mass reduction approach without dewatering as a second phase, making them less effective than the SPC-6 and SPC-7 alternatives. Without dewatering, the groundwater mound in South Plants is not reduced, which may cause additional groundwater migration. After the mass reduction phase, residual contaminants are not removed by the dewatering system.

Alternative SPC-5/SPT-2/SPT-5 is expected to be somewhat more effective than the SPC-3 alternatives because the South Tank Farm Plume is remediated with in situ biodegradation rather than aboveground treatment. In situ treatment involves treatment in the aquifer and recirculation of water and is therefore expected to provide a higher degree of contaminant reduction in the aquifer than achieved through extraction and treatment. However, in situ biodegradation is less demonstrated.

Of the remaining alternatives, those that include the SPC-3 controls provide comparable long-term effectiveness to SPC-5. These alternatives use a mass reduction approach to extract contaminated groundwater near the contamination source in the South Plants North Source, South Plants Southeast, and South Tank Farm Plumes, and thus minimize contaminant migration on post. The SPC-3 alternatives include air stripping, GAC adsorption, and direct biological treatment. All of the treatment technologies are equally effective in the long term, making the SPC-3 alternatives equal under this criterion.

Alternative SPC-1 is substantially less effective in the long term than any of the other alternatives. The alternative allows continued contaminant migration on post, including potential vertical migration into deeper aquifer zones. Continued migration increases the potential for exposure because the contaminant mass remains in the aquifer and eventually increases loading on the boundary systems.

9.5.4 Reduction of TMV

The reduction in toxicity is dependent on the type of treatment that is being used, and reductions in mobility and volume are dependent on the groundwater controls that are being used.

Alternatives SPC-7/SPT-2/SPT-5 and SPC-7/SPT-3/SPT-5 result in the greatest decrease in mobility and volume because of the large volume of groundwater that is extracted and treated during both the mass reduction and dewatering phases, which, combined with the cap prevents

further infiltration and leaching of contaminants. Contaminant mobility is also controlled by the dewatering phase because it prevents continued migration.

Both Alternatives SPC-7/SPT-2/SPT-5 and SPC-7/SPT-3/SPT-5 reduce the toxicity of the groundwater either by treatment with air stripping (with catalytic oxidation of the vapor emissions) followed by GAC adsorption, or with ozone/hydrogen peroxide oxidation followed by GAC adsorption, respectively. Both of these treatment processes irreversibly remove contaminants from the extracted water.

Oxidation has the advantage that the contaminants are destroyed in the oxidation unit, while the other processes involve transfer of the contaminants to a different medium. GAC treatment involves adsorption of the contaminant onto the carbon, which is thermally regenerated off-post. Air stripping also involves transfer of the contaminants from the water into the air stream. Contaminants are subsequently destroyed in the catalytic oxidation unit. Therefore, Alternative SPC-7/SPT-3/SPT-5 is a more efficient treatment process than Alternative SPC-7/SPT-2/SPT-5. Both alternatives produce about the same amount of waste, but Alternative SPC-7/SPT-2/SPT-5 consumes more carbon than Alternative SPC-7/SPT-3/SPT-5.

The next most effective alternatives are Alternatives SPC-6/SPT-2/SPT-5 and SPC-6/SPT-3/SPT-5, which are identical to Alternatives SPC-7/SPT-2/SPT-5 and SPC-7/SPT-3/SPT-5 except that they do not include a cap over the South Plants Central Processing Area. These alternatives also result in a large reduction in volume of contaminated water because of the mass reduction and dewatering phases. The reduction in mobility is not as effective as for the SPC-7 alternatives because there is no cap to retard recharge in the South Plants Central Processing Area.

The treatment technologies are the same as those considered for the SPC-7 alternatives. As discussed above, both treatment alternatives irreversibly remove contaminants, but Alternative SPC-6/SPT-3/SPT-5 consumes less carbon than Alternative SPC-6/SPT-2/SPT-5.

Except for Alternative SPC-1, the remaining alternatives consist of mass reduction extraction systems without the additional dewatering phase. The SPC-3 alternatives and Alternative SPC-5/SPT-2/SPT-5 remove a smaller volume of water overall than the SPC-6 and SPC-7 alternatives. In addition, the groundwater mound in South Plants is allowed to remain. The SPC-3 alternatives remove the next greatest volume of water for treatment. These include four treatment options: air stripping followed by GAC adsorption (SPC-3/SPT-2), ozone/hydrogen peroxide oxidation followed by GAC adsorption (SPC-3/SPT-3), air stripping followed by GAC adsorption plus direct biological treatment followed by GAC adsorption (SPC-3/SPT-2/SPT-4), and UV/hydrogen peroxide oxidation followed by GAC adsorption plus direct biological treatment followed by GAC adsorption (SPC-3/SPT-3/SPT-4). All of these alternatives include catalytic oxidation of vapor emissions from the air strippers and oxidation units, and all remove or destroy contaminants irreversibly, but Alternatives SPC-3/SPT-2/SPT-4 and SPC-3/SPT-3/SPT-4 generate slightly more waste due to the biological system, and Alternative SPC-3/SPT-2 has the greatest annual carbon consumption of all the alternatives.

Alternative SPC-5/SPT-2/SPT-5 is the same as Alternative SPC-3/SPT-2/SPT-4 except that the former includes in situ biodegradation rather than direct biological treatment in the South Tank Farm Plume. The result is that less groundwater is extracted and treated aboveground than in the SPC-3 alternatives, although the reduction in mobility is comparable for both alternatives.

Alternative SPC-1 provides marginal reduction in TMV because it relies on natural attenuation only. Leaving groundwater contamination in the South Plants area increases the potential for this contamination to migrate vertically into deeper aquifers where it will be more difficult to remediate and where it may migrate in unexpected directions.

9.5.5 Short-Term Effectiveness

All of the alternatives considered for the South Plants Plume Group have minimal impact on the environment, surrounding communities, and workers. The two SPC-7 alternatives have the same

potential for impact because they include demolition of structures and installation of a cap over the South Plants Central Processing Area; the impact, however, is still expected to be negligible.

RAOs are achieved at the RMA boundary by systems other than the South Plants groundwater alternatives. The SPC-3 alternatives and Alternative SPC-5/SPT-2/SPT-5 are expected to operate for 10 years, while the SPC-6 and SPC-7 alternatives are expected to operate for at least 100 years. Alternative SPC-1 requires no activity.

9.5.6 Implementability

All of the alternatives being considered for the South Plants Plume Group are administratively feasible. They are also technically feasible, although some are more easily implemented than others.

The control technologies used in the alternatives consist of extraction wells, injection wells and trenches, and a clay/soil cap. These are all proven, reliable, and available technologies that are currently in use at RMA.

Treatment alternatives consist of various combinations of the following technologies: air stripping, GAC adsorption, oxidation (ozone/hydrogen peroxide or UV/hydrogen peroxide), direct biological treatment, and in situ biodegradation. Of these, air stripping and GAC adsorption are proven, reliable, and available technologies that are currently in use at RMA. Therefore, the only alternative that utilizes these technologies, Alternative SPC-3/SPT-2, is the most readily implementable of the alternatives.

Chemical oxidation is considered innovative and requires treatability studies, making implementation and operation somewhat more complex than for the proven technologies. The alternatives that are more difficult to implement than those involving proven technologies only are Alternatives SPC-3/SPT-3/SPT-5, SPC-6/SPT-3/SPT-5, and SPC-7/SPT-3/SPT-5.

Direct biological treatment and in situ biodegradation both require close oversight and necessitate treatability studies and operator training. Alternatives that include biological treatment in combination with air stripping and GAC adsorption are the least implementable. These are Alternatives SPC-3/SPT-2/SPT-4, SPC-5/SPT-2/SPT-5, SPC-6/SPT-2/SPT-5, and SPC-7/SPT-2/SPT-5.

Alternative SPC-1 is already in place, so this alternative is the most easily implemented of all the alternatives.

9.5.7 Cost

The alternatives tend to fall into three cost categories: high, medium, or low. Alternative SPC-1, with a present worth cost of $1,800,000, is significantly less costly than any of the other alternatives.

Alternatives that fall into the medium cost group are those that use mass reduction, but do not include a dewatering phase. In this group are Alternatives SPC-3/SPT-2, SPC-3/SPT-3, SPC-3/SPT-2/SPT-4, SPC-3/SPT-3/SPT-4, and SPC-5/SPT-2/SPT-5. For this group, capital costs range from $3,730,000 to $5,650,000 and present worth cost from $10,500,000 to $13,500,000.

Alternatives in the highest cost group are those that include an extended dewatering phase. There are four alternatives in this group with capital costs ranging from $6,100,000 to $7,680,000; their present worth cost ranges from $17,400,000 to $19,100,000. Included in this group are Alternatives SPC-6/SPT-2/SPT-5, SPC-6/SPT-3/SPT-5, SPC-7/SPT-2/SPT-5, and SPC-7/SPT-3/SPT-5.

9.5.8 Selection of Preferred Alternative

The preferred alternative for the South Plants Plume Group is Alternative SPC-7/SPT-2/SPT-5 (Table 9.5-1), in which groundwater is controlled through mass reduction and cap installation over the South Plants Central Processing Area followed by dewatering. Treatment is

accomplished with air stripping followed by GAC adsorption and in situ biodegradation (for the South Tank Farm Plume). This alternative is preferred because mass reduction of the plumes removes the maximum contaminant mass for the given period of operation, and the dewatering of the mound ensures that groundwater migration out of South Plants is minimized.

This alternative employs a phased approach, with mass reduction of the South Plants plumes occurring in the first phase as soil and structures remedial activities in the South Plants Central Processing Area proceed. Mass reduction of the South Tank Farm Plume is expected to be accomplished by in situ biodegradation. An additional 2 gpm is extracted from the South Plants North Source and Southeast Plumes during the first phase and treated with Basin A groundwater. When structures and soil remedial activities are completed in South Plants, wells are added to create a dewatering grid in the South Plants groundwater mound area. Once complete, the mound dewatering grid ensures hydraulic gradient control, and minimizes the migration of contaminants from the South Plants area. Alternative SPC-7 is identical to Alternative SPC-6 except that it includes a cap over the South Plants Central Processing Area as proposed in the Soils DAA. Any LNAPL encountered in the South Tank Farm Plume is separated by a dual-pump system.

In situ biodegradation destroys the benzene in the South Tank Farm Plume. Air stripping and GAC adsorption are used to treat the organics in the remainder of the South Plants Plume. Catalytic oxidation destroys the organics in the air stripper emissions. GAC is thermally regenerated off post. Extracted LNAPL is collected and transported off post for thermal destruction.

Table 9.0-1 Summary of Preferred Alternatives

Plume Group	Alternative	Description	Percent Worth Cost	Total Cost*
Northwest Boundary	NWC-2	Continued Existing Action	$20,100,000	$38,000,000
Western	WC-2	Continued Existing Action	$14,500,000	$27,300,000
North Boundary	NC-2	Continued Existing Action	$41,200,000	$77,800,000
Basin A	AC-3/AT-2	Mass Reduction, Stripping/Sorption	$30,300,000	$48,700,000
South Plants	SPC-7/SPT-2/SPT-5	Mass Reduction/Dewatering, Stripping/Sorption, In Situ Biodegradation	$18,800,000	$31,800,000

* Total cost is the non-discounted cost of the alternative

Table 9.1-1 Selection of Preferred Alternatives - Northwest Boundary Plume Group

Retained Alternatives from DSA	Selected Alternative	Rationale for Selection
NWC-1: No Action NWC-2: Continued Existing Action	NWC-2: Continued Existing Action	The NWBCS is effective and in place. The system has been upgraded through IRAs. With the Basin A Neck IRA operating, and very low contaminant levels present in the Sand Creek Lateral Plumes, additional control or treatment alternatives does not improve effectiveness.

Table 9.2-1 Selection of Preferred Alternatives - Western Boundary Plume Group

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Retained Alternatives from DSA	Selected Alternative	Rationale for Selection
WC-1: No Action WC-2: Continued Existing Action	WC-2: Continued Existing Action	The ICS is effective and in place. With the Motor Pool Plume and Railyard Plume IRAs in place and very low contaminant levels that originate off post in the Western Plume, additional control or treatment alternatives do not improve effectiveness of the systems in place.

Table 9.3-1 Selection of Preferred Alternatives - North Boundary Plume Group

Retained Alternatives from DSA	Selected Alternative	Rationale for Selection
NC-1: No Action NC-2: Continued Existing Action NC-3/NT-2: Basins C and F Interception, Sorption at NBCS NC-3/NT-3: Basins C and F Interception, Stripping/Sorption NC-3/NT-4: Basins C and F Interception, Oxidation NC-6: Basins C and F Clay/Soil Cap	NC-2: Continued Existing Action	The NBCS provides protection of human health and the environment off post by extraction and treatment at the boundary. Alternative NC-2 was selected because the benefit of additional extraction/treatment on post is small. This system incorporates the existing Basin F IRA as well. No additional action is required for the North Plants Plume due to low levels of contamination.

Table 9.4-1 Selection of Preferred Alternatives - Basin A Plume Group

Page 1 of 1

Retained Alternatives from DSA	Selected Alternative	Rationale for Selection
AC-1: No Action AC-2: Continued Existing Action AC-3/AT-2: Mass Reduction, Stripping/Sorption AC-3/AT-4: Mass Reduction, Stripping/Oxidation/ Sorption AC-7: Capping	AC-3/AT-2: Mass Reduction, Stripping/Sorption	Alternative AC-3/AT-2 is accomplished in conjunction with the soils capping alternative and is also coordinated with the selected South Plants alternative. The majority of high-level contamination is removed from groundwater during the 10-year mass reduction phase and reduces any remaining contamination through the installation of the clay/soil cap. Any residual groundwater contamination is removed by the Basin A Neck IRA or the boundary systems. Air stripping effectively removes most of the chloroform and benzene from water. GAC adsorption removes residual chloroform, benzene, and pesticides. Vapor emissions containing chloroform and benzene are subsequently destroyed by catalytic oxidation. GAC is thermally regenerated off post.

Table 9.5-1 Selection of Preferred Alternatives South Plants Plume Group

Retained Alternatives from DSA	Selected Alternative	Rationale for Selection
SPC-1: No Action SPC-3/SPT-2: Mass Reduction, Stripping/Sorption SPC-3/SPT-3: Mass Reduction, Oxidation, Sorption SPC-3/SPT-2/SPT-4: Mass Reduction, Stripping/Sorption, Biological Reactor/Sorption SPC-3/SPT-3/SPT-4: Mass Reduction, Oxidation/Sorption, Biological Reactor/Sorption SPC-5/SPT-2/SPT-5: Mass Reduction, Stripping/Sorption, In Situ Biodegradation	SPC-7/SPT-2/SPT-5: Mass Reduction/Dewatering, Capping, Stripping/Sorption, In Situ Biodegradation	Alternative SPC-7/SPT-2/SPT-5 is selected because the hydrogeologic conditions favor mass reduction of the plumes along with lowering of the groundwater mound. The alternative uses a phased approach with mass reduction of the plumes in the first phase as soil and structures remediation proceeds. The mass reduction of the South Tank Farm Plume is expected to be accomplished by in situ biodegradation. An additional 2 gpm is extracted from the South Plants North Source and Southeast Plumes during the first phase and treated with Basin A groundwater. When structures and soil remediation activities are completed in South Plants, wells are added to the mound dewatering grid. Once complete, the mound dewatering grid ensures hydraulic gradient control, and minimizes migration of contaminants from the South Plants area. Alternative SPC-7 is identical to SPC-6 except that it includes the installation of a cap over the South Plants Central Processing Area as proposed in the Soils DAA. Any LNAPL encountered in the South Tank Farm Plume is separated by a dual-pump system. In situ biodegradation destroys benzene in the South Tank Farm Plume. Air stripping and GAC adsorption is used to treat the organics in the remainder of the South Plants Plume Group. Catalytic oxidation destroys the organics in the air stripper emissions. GAC is thermally regenerated off post. Extracted LNAPL is collected and transported off post for thermal destruction.

Table 9.5-1 Selection of Preferred Alternatives South Plants Plume Group

Retained Alternatives from DSA	Selected Alternative	Rationale for Selection
SPC-6/SPT-2/SPT-5: Mass Reduction/Dewatering, Stripping/Sorption, In Situ Biodegradation		
SPC-6/SPT-3/SPT-5: Mass Reduction/Dewatering, Oxidation/ Sorption, In Situ Biodegradation		
SPC-7/SPT-2/SPT-5: Mass Reduction/Dewatering and Capping, Stripping/ Sorption, In Situ Biodegradation		
SPC-7/SPT-3/SPT-5: Mass Reduction/Dewatering and Capping, Oxidation/ Sorption, In Situ Biodegradation		

10.0 COMBINED BASIN A/SOUTH PLANTS TREATMENT PLANT

The preferred alternatives for the Basin A Plume Group and South Plants Plume Group both include groundwater extraction and treatment with air stripping and GAC adsorption. Because these two plume groups are adjacent, and because they use the same treatment technologies, some savings can be realized if their treatment systems are combined. The LNAPL extraction system and in situ biodegradation system in the South Tank Farm Plume are kept as separate systems.

This combined alternative uses the same extraction systems that are used for Alternatives AC-3 and SPC-7. During the first 10 years (Phase 1), groundwater in the South Plants Southeast, South Plants North Source, Basin A, and Section 36 Bedrock Ridge Plumes is extracted using the extraction wells (Figure 10.0-1). This produces a total of 12 gpm that is piped to a holding tank at the treatment plant. After treatment, the water is reinjected through two reinjection trenches located in Section 27.

The treatment plant is the same as that described for Alternative AC-3/AT-2 (Section 7.3.1.2). The flow contribution from South Plants is only 2 gpm and can be combined with the flow from Basin A without resizing any of the equipment specified for Alternative AC-3/AT-2. The major pieces of equipment are the collection tank, a multimedia filter, an air stripper with catalytic oxidation of the air emissions, GAC adsorbers, a bag filter, and an effluent collection tank.

Alternatively, the CERCLA Wastewater Treatment Plant could potentially be used during Phase 1 to treat the extracted South Plants and Basin A water. This is dependent on the available capacity of the treatment plant during this time, and would require modifications to the existing system to accommodate continuous operation instead of the current semibatch mode of operation.

In situ biodegradation is used to treat groundwater in the South Tank Farm Plume. Any LNAPL encountered in this area is extracted using a dual-pump system and disposed appropriately. This system, which is the same as the one described for Alternative SPC-5/STP-2/SPT-5 (Section 8.6.1), consists of three lines of extraction wells and three sets of reinjection wells in the center

of the plume. The extracted water is enriched with oxygen and nutrients to promote biodegradation before it is reinjected.

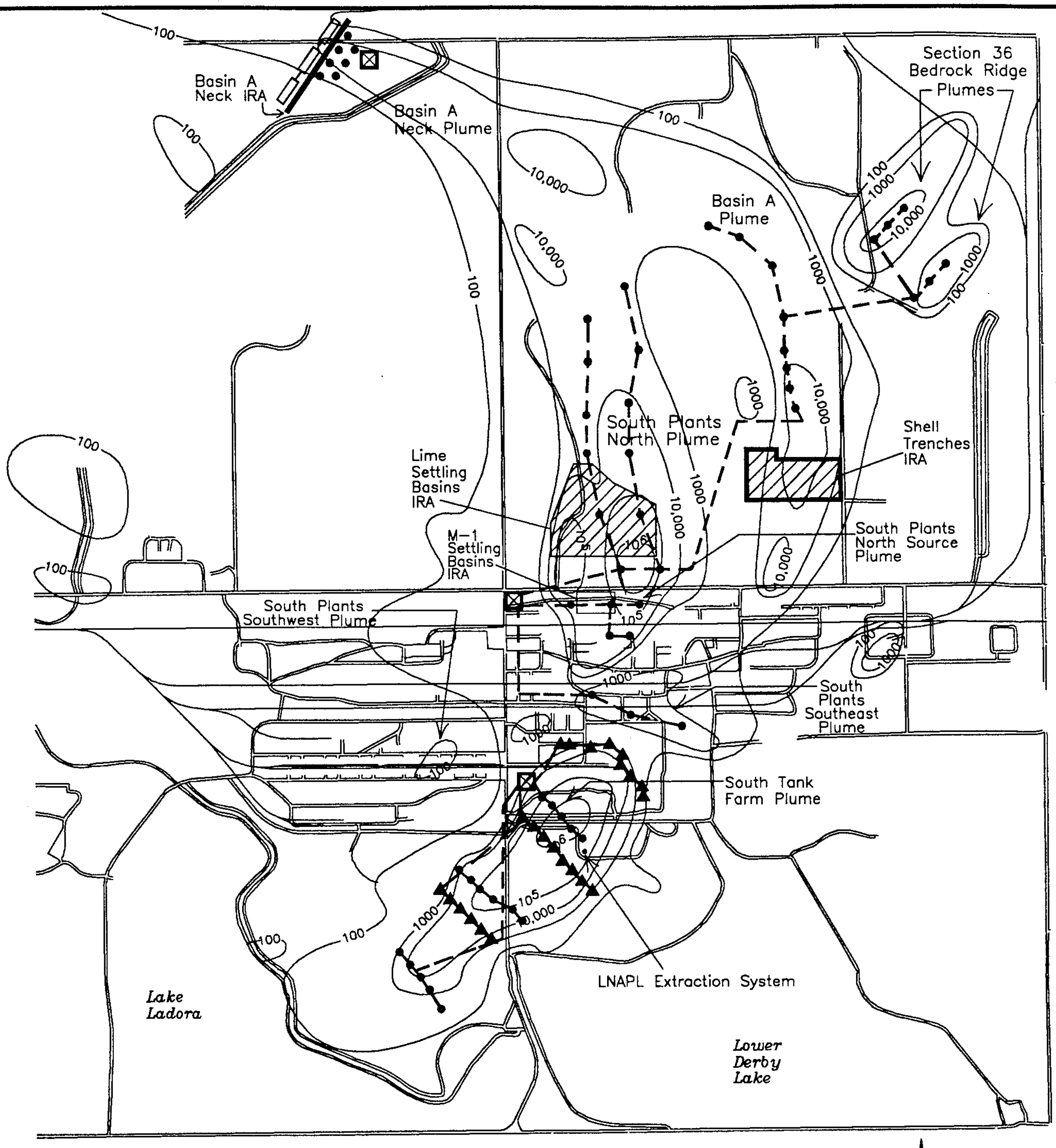
When Phase 1 is completed (after 10 years), the extraction system in Basin A is shut down and a dewatering grid is installed in South Plants. Phase 2 consists of dewatering South Plants with the extraction well grid that is described in Section 8.7.1.1 and shown in Figure 10.0-2. This is expected to operate for up to 100 years and produces 25 gpm. The extracted water is treated at the Basin A/South Plants combined treatment plant and after treatment is reinjected at the recharge trenches. The same treatment plant is used as for Phase 1, but because the flow is increased from 12 gpm to 25 gpm, a new air stripper is needed to replace the existing one. The remaining equipment is large enough to accommodate the increased flow.

Use of the CERCLA Wastewater Treatment Plant during Phase 2 is a less likely option. The plant has a design capacity of 15 gpm, with a maximum capacity of 30 gpm. It is also needed for treatment of purge water and other wastewater streams that may be generated during this time. It does not appear that the plant will have the capacity to treat a continuous stream of 25 gpm in addition to its other influent streams. Therefore, the plant is not considered for treatment of the extracted water from Phase 2.

The combined treatment approach alternative represents a change in the physical layout of the preferred alternatives for the Basin A and South Plants Plume Groups. It does not impact the performance or effectiveness of the preferred alternatives in any way. The only change is that the cost of combined treatment is less than the sum of the two individual treatment systems because only one building is required and only one set of support equipment (e.g., holding tanks, pumps, filters, etc.) is needed.

The capital cost for this combined extraction and treatment alternative (i.e., combining Alternatives AC-3/AT-2 and SPC-7/SPT-2/SPT-5) is $11,900,000. The annual O&M costs for years 1 to 5 are $2,400,000, costs for years 6 to 10 are $2,390,000, and costs for the remaining

20 years are $2,070,000. The present worth cost of the alternative is $47,700,000. This compares to $49,100,000 for the two alternatives with separate treatment systems. A summary of costs is presented in Appendix A, Table A6-1.



N

Not To Scale

LEGEND

▨ Cap

—100— Summed Concentration of organic analytes (Table 3.1-2) in unconfined aquifer (ug/L)

● Extraction Well

▲ Injection Well

▭ Recharge Trench

━ Slurry Wall

– – – Transport Pipe

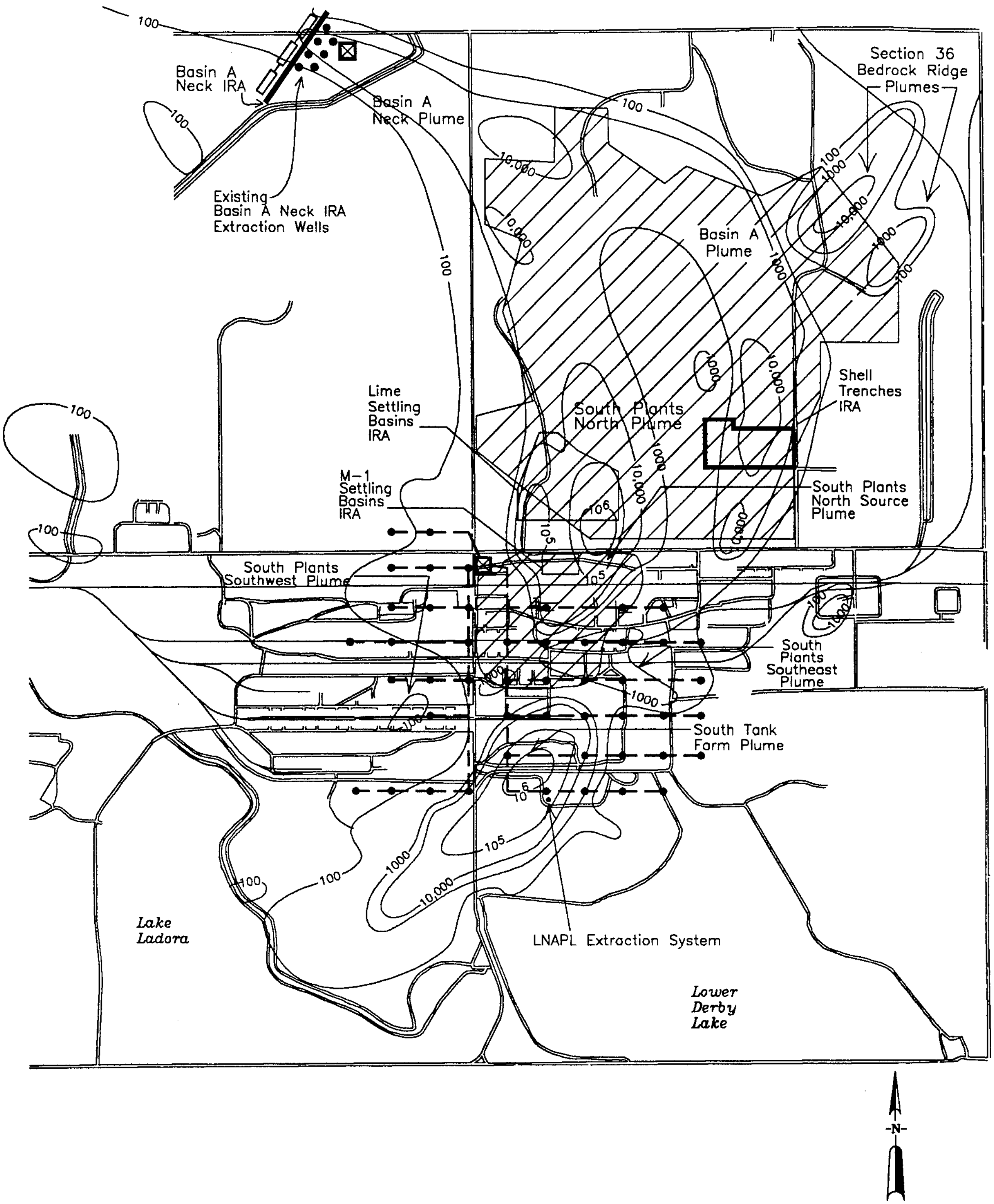
⊠ Treatment Plant

SOURCE: Water DSA Plume Map

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 10.0-1
Schematic for South Plants Plume Group
Control Alternative AC-3/SPC-7
Phase I (Years 1-10)

Prepared by:
EBASCO SERVICES INCORPORATED



LEGEND

▨ Cap

−100↘ Summed Concentration of organic analytes (Table 3.1−2) in unconfined aquifer (ug/L)

● Extraction Well

▭ Recharge Trench

━━ Slurry Wall

− − − Transport Pipe

☒ Treatment Plant

Not To Scale

SOURCE: Water DSA Plume Map

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 10.0−2
Schematic for South Plants Group
Control Alternative AC−3/SPC−7
Phase II (Years 11−30)

Prepared by:
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APPENDIX A
COST ESTIMATES

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APPENDIX A6 - COST ESTIMATE - COMBINED BASIN A AND SOUTH PLANTS PLUME GROUPS

A1.0 INTRODUCTION

This appendix contains the cost estimates for the alternatives evaluated in the Detailed Analysis of Alternatives (DAA) for the Northwest Boundary, Western, North Boundary, Basin A, and South Plants Plume Groups in the water medium.

The cost estimates for alternatives developed for the Northwest Boundary Plume Group are presented in Tables A1-1 and A1-2, those for the Western Plume Group in Tables A2-1 and A2-2, those for the North Boundary Plume Group in Tables A3-1 through A3-6, those for the Basin A Plume Group in Tables A4-1 through A4-5, those for the South Plants Plume Group in Tables A5-1 through A5-10, and those for the combined Basin A and South Plants Plume Group in Table A6-1.

The following sections explain the format of the cost estimate tables and discuss the methodology used to develop the unit rates and indirect cost factors appearing in the tables.

A2.0 COST ESTIMATE TABLES

The cost estimates presented in the tables of this appendix detail the following four cost categories:

- Direct Capital Costs
- Indirect Capital Costs
- Direct Operations and Maintenance Costs
- Indirect Operations and Maintenance Costs

Capital costs are those costs incurred to purchase and install the control and treatment systems (e.g., the purchase of an air stripping unit). Operations and Maintenance (O&M) costs are those incurred to actually extract and treat the groundwater (e.g., the operation and maintenance of the air stripper).

Direct costs include costs to purchase, build, and operate equipment at the site. Indirect costs include the following:

- Mobilization and demobilization
- Indirects, overhead, and profit
- Engineering design
- Resident engineering
- Contingency

The headings across the top of each cost estimate are explained as follows:

Cost Item:	Represents a unit operation and its associated direct cost.
Cost Type:	Represents the cost incurred: "LS" for lump sum for a unit operation that occurs in only year 1, or "A" for annual cost for a unit operation that occurs in only year 1.
Start Year:	Represents the starting year for the unit operation. Cardinal numbers are used to specify the calendar year with year 1 representing 1995.

End Year:	Represents the ending year for the unit operation. Note that no ending year is specified for the lump sum cost type. Cardinal numbers are used to specify the calendar year with year 1 representing 1995.
Unit Cost:	Represents unit cost for the particular unit operation in 1992 dollars.
Units:	Represents units associated with the 1992 ($) unit cost. Each unit begins with a slash (/), indicating the units are in the denominator of the 1992 ($) Unit Cost and Units pair.
Quantity:	Represents quantity of each unit.
Units:	Represents units associated with the Quantity.
1995 ($) Annual Cost:	Represents the annual costs for the O&M portion of the cost estimates for the time period indicated (e.g., YR 1-5, YR 6-10, YR 11-30)
1995 ($) Total Cost:	Represents total cost in 1995 dollars, which is calculated by multiplying these factors as follows: • 1992 ($) Unit Cost • Quantity • Single Payment Compound Amount Factor to convert the 1992 ($) Unit Cost to a 1995 ($) Unit Cost using a 4.5-percent discount rate. This factor equals 1.141.
1995 ($) PW Cost:	Represents present worth cost in 1995 dollars, which is calculated by applying the appropriate fraction of the 1995 ($) Total Cost to the specified years, then discounting the applied value at each year back to Year 1 1995 ($) using a 4.5 percent discount rate.

Explanations for calculations for all subtotals and all indirect costs are given on the estimate tables in the form of alphabetical references to computed values. It should be noted, these cost estimates are structured solely to represent a comparative cost between site-wide alternatives and not as stand alone estimates. Caution should be exercised in comparing individual alternative costs such as design; resident engineering; and indirects, overhead and profit since these costs represent only a comparative percentage of any one individual alternative. Prior to

implementation of the preferred alternatives developed in this document it will be necessary to re-evaluate the total estimated cost to provide a more detailed cost assessment.

A3.0 UNIT RATE DEVELOPMENT

A3.1 NO ACTION

No Action line item costs include the plume evaluation monitoring and slurry wall demolition.

A3.1.1 Plume Evaluation Monitoring

Costs for plume evaluation monitoring include the disposal of purge water and the analysis of groundwater samples (including quality assurance/quality control (QA/QC) samples).

A3.1.2 Slurry Wall Demolition

Since the trenches used to demolish the slurry wall are similar in design to reinjection trenches (i.e., 10 ft long with a depth to the base of the slurry wall), the same unit cost per square foot for installation cost is used. Approximately nine trenches are to be constructed through the North Boundary Containment System (NBCS) and approximately four through the Northwest Boundary Containment System (NWBCS) and Basin A Neck Interim Response Action (IRA) slurry walls each.

A3.2 CONTINUED EXISTING ACTION

Continued Existing Action line items include the costs of continuing to operate the boundary systems as well as existing IRAs. These costs are derived from the costs already associated with operating these systems. Since these systems have already been built, only annual O&M costs are considered. These costs do not include replacement of any of the major equipment or plume evaluation monitoring. The costs range from $401,000 annually for the continued operation of the Irondale Control System (ICS) to $1,180,000 annually for the NBCS.

A3.3 MONITORING

Monitoring line item costs include performance monitoring of the extraction and reinjection systems and plume evaluation monitoring and process monitoring of the treatment system. Monitoring is calculated as annual O&M costs.

A3.3.1 Performance Monitoring Well Installation

Costs for performance monitoring well installation are $30/ft including materials, drill rig, labor for an operator and helper, and mobilization/demobilization (Stine 1992). Additional costs include labor for a decontamination technician, geologist, and health and safety technician, personal protective equipment (PPE) for drilling and well development personnel, and waste handling.

Well installation was assumed to be completed in Level C protection and to require approximately 12 hours (hrs)/well. Labor rates are $33/hr for a decontamination technician and $49/hr for a geologist and health and safety technician each. Well development requires a geologist and health and safety technician and takes approximately 4 hrs/well.

PPE costs cover a four-man crew for drilling operations and a two-man crew for well development. The unit rates are $5,850 and $1,700/well, respectively, including monitoring equipment.

Waste-handling costs include Toxicity Characteristic Leaching Procedure (TCLP) analysis for each well and disposal of six drums containing well cuttings and development water. Unit costs are $1,500 and $390/well, respectively.

For costing purposes, well installation for Basin A was assumed to require Level B protection. This requires additional health and safety monitoring equipment and personnel, and increases by 25 percent the per-foot rate for drilling and hours required for well installation and development. Well installation in all other areas was assumed to be in Level C. This is for costing only and work in Level B installation may occur in other areas besides Basin A, but it was assumed the higher percentage of work is conducted be in Level C. The actual level of protection is determined in the workplace prior to performance of work.

A3.3.2 Performance and Plume Evaluation Monitoring

The number of monitoring wells proposed reflects estimates made strictly for costing purposes. The actual number of monitoring wells required will be determined during the design phase. In addition, the initial number of monitoring wells sampled during system operation may decrease over time depending on system performance.

Performance monitoring includes only the wells that are used specifically to monitor the performance of extraction and reinjection systems. The number of wells varies depending on the alternative. Costs for performance well monitoring were derived by estimating the number of wells required for adequate evaluation of system performance. These wells were assumed to be sampled quarterly for 3 years for target analytes and annually for 27 years for full-suite analysis. Cost for target analyte and full-suite analyses are $500 and $2,000/sample, respectively. Quality assurance/quality control (QA/QC) sampling includes an additional 30 percent of the total number of samples taken and includes trip blanks, rinse blanks, and duplicates. Additional costs include $65/drum for labor, transportation, handling, disposal and drum purchase. It was assumed that three well purge volumes per well require three drums for disposal. The number of years required for monitoring varies depending on system performance.

Plume evaluation monitoring costs were derived by assuming 100 wells are monitored annually for 10 years and once every 5 years for the next 20 years. These wells are divided on a percentage basis between the alternatives. Costs include sampling and purge water disposal. Sampling costs are $2,000/sample analyzed, including 30 percent additional samples for QA/QC purposes. Purge water disposal costs are $65/drum including labor, transportation, handling, disposal, and drum purchase. The actual number of monitoring wells needed is determined in the work plan for the monitoring program.

A3.3.3 Process Monitoring

The Process Monitoring line item includes the costs of monitoring the influent and effluent streams to ensure proper operation of the treatment system.

Process monitoring includes the costs to analyze different contaminants. The contaminants that are to be monitored were determined on the basis of Target Effluent Concentration (TEC) exceedances. The costs of these analyses range from $60/sample for dibromochloropropane (DBCP) to $300/sample for organophosphorus compounds, GB Agent Related (OPHGBs). The costs of the sample containers and shipping to the analytical laboratory are estimated at $20 and $40, respectively, per sampling event. The total cost per sampling event is the sum of the analytical costs, sample containers, and shipping.

Process monitoring includes one influent and one effluent sample per week. In the case of in situ biodegradation, where no treatment takes place aboveground, only one sample is collected per week.

Labor is included in this line item as operation and supervisory labor. The operator, at $13.50/hr, requires 1 hr/week to complete the sampling required. Supervisory labor is included at 130 percent of the operator's wages and 15 percent of the operator's time. The supervisor's functions consist of overseeing the sampling and preparing the report.

A3.4 CONTROL SYSTEM INSTALLATION

Control system installation costs include extraction well and pump installation, injection well installation, extraction and reinjection pipe installation, and recharge trench installation.

Extraction Well and Pump Installation line item costs range from $19,820 to $794,200. The costs for reinjection well installation for Alternative SPC-5 are $264,900. Extraction and reinjection pipe costs, including controls and system hookups, range from $3,240 to $557,200. Recharge trench costs are a lump sum of $174,000 for all applicable alternatives.

Extraction and reinjection wells are of similar design in that both are constructed of 6-inch Schedule 40 polyvinyl chloride (PVC) and placed in a 12-inch borehole to enhance water flow to and from the well.

A3.4.1 Extraction Wells and Pump Installation

Costs for extraction well installation are $45/ft including materials, drill rig, labor for an operator and helper, and mobilization/demobilization (Stine 1992). Additional costs include labor for a decontamination technician, geologist, and health and safety technician, PPE for drilling and well development, waste handling, pump installation, and geotechnical analysis.

Well installation was assumed to be in Level C protection and to require approximately 12hrs/well. Labor rates are $33/hr for a decontamination technician and $49/hr for a geologist and health and safety technician each. Well development requires a geologist and health and safety technician for approximately 4 hrs/well.

PPE costs cover a four-man crew for drilling operations and a two-man crew for well development. The unit rates are $5,850 and $1,700/well, respectively, including monitoring equipment.

Waste-handling costs include TCLP analysis for each well and disposal of six drums containing well cuttings and development water. Unit costs are $1,500 and $390/well, respectively.

Pump installation costs include $860/well for the purchase price of a one-third-horsepower pump with teflon seals (Hasslen 1992). The material and labor costs for the installation of these pumps are included in the cost of the extraction system installation.

Geotechnical analysis includes two samples per well for permeability testing, sieve analysis (using a 200-micron sieve), and a hydrometer test at $225/sample for a total of $500/well (Cochran 1992).

For costing purposes, well installation for Basin A was assumed to require Level B protection. This requires additional health and safety monitoring equipment and personnel, and increases by 25 percent the per-foot rate for drilling and hours required for well installation and development.

Well installation in all other areas was assumed to be in Level C. This is for costing only, and work in Level B may occur in other areas besides Basin A, but it was assumed the higher percentage of work is performed in Level C. The actual level of protection is determined in the work plan prior to performance of work.

A3.4.2 Injection Well Installation

Costs for Injection Well Installation line items are identical to the costs for extraction wells, excluding pump installation and geotechnical analysis.

A3.4.3 Extraction Pipe and System Installation

Costs for extraction pipe and system installation include labor and materials for extraction and booster pump installation including controls and power line, pipe installation, and PPE for pipe burial.

Extraction pump installation costs include the labor costs for one electrician, trenching for conduit burial, controls, tanks, and the hookup and installation of a submersible pump for each well. It was assumed that installation of each pump requires an average of 4 hours, for a total of $750/well. The cost for collection tanks for each system and associated controls for the tanks and pumps is $2,170/well.

Booster system costs include the purchase of two 1.5 horsepower pumps at $1,500 each (Fehringer 1992). One pump is used as a backup should repairs be required to the primary pump. Materials for booster system installation were assumed to be 15 percent of the total extraction pipe and system installation. Labor costs for booster pump installation include one electrician for 4 hrs/pump at a rate of approximately $40/hr.

The cost for power line installation, including materials and labor, is approximately $8/ft. Pipe materials and installation costs for a 2-inch carrier pipe inside a 3-inch containment pipe is

approximately $14/ft. The unit cost for piping installation in Basin A, Basins C and F, and South Plants areas were increased to cover PPE requirements.

A3.4.4 Reinjection Pipe and System Installation

Costs for reinjection pipe and system installation include labor and materials for booster pump installation, including controls and pipe installation.

Booster system costs include the purchase of two 1.5-horsepower pumps at $1,500 each (Fehringer 1992). One pump is to be used as a backup should repairs be required to the primary pump. Materials for booster system installation were assumed to be 15 percent of the total reinjection pipe and system installation. Labor costs for booster pump installation include one electrician for 4 hrs/pump at a rate of approximately $40/hr.

Pipe materials and installation costs for a 2-inch Schedule 40 PVC pipe is approximately $5/ft. The unit cost for installation of the pipe, pumps, and controls is increased by a factor of 25 percent for Basin A since this area is more highly contaminated.

A3.4.5 Recharge Trench Installation

The costs for recharge trench installation include mobilization/demobilization and materials and labor. The mobilization/demobilization cost is a lump sum of $30,000 and the costs for excavation, burial, bioslurry, gravel pack, geotextile, perforated pipe for injection and monitoring, and labor are included in the unit cost of $12/square foot (SF) (Hanford 1992).

A3.5 WELL PUMP OPERATIONS AND MAINTENANCE

The well pump operations and maintenance costs include well and pump operations and maintenance and repair. The costs for these line items range from $510 to $6,931 and $1,360 to $88,600 respectively.

A3.5.1 Well and Pump Operations

Well and Pump Operations line item costs include the utility costs for operation of booster and submersible pumps. The pumps were assumed to operate 24 hrs/day for 330 days/yr due to 10 percent down time per year. The cost per kilowatt hour is $0.04.

A3.5.2 Maintenance and Repair

Maintenance and Repair line item costs include labor, well cleaning, pump replacement, and maintenance vehicle. Costs for labor are derived by assuming that one person, at a rate of $33/hr, is able to perform the required periodic checks and adjustments in 2 hrs/day or 520 hrs/year(yr). Well cleaning costs include yearly backflushing of the sand pack, additives for limiting biological growth, sediment removal from the sand trap, and brushing of the casing for an average cost of $1,360/well. Pump replacement for each well is expected to take place every 5 years for a cost of $860/well. Costs for pump replacement are converted to an annual present worth value using 4.5 percent interest for 30 years. The project vehicle costs $33/day and is needed 65 days/yr/system for a total cost of $2145/yr/system.

A3.6 CLAY/SOIL CAP

The Soil Capping line item costs for Alternative NC-6 are $14,700,000. The unit cost for capping is being estimated as part of the development of alternatives for the soils medium and is detailed in the soils DAA. The unit cost used is approximately $23/SY of capital costs and a cap maintenance annual O & M cost of $0.80/SY.

A3.7 TREATMENT

A3.7.1 Treatment Facility

The Treatment Facility line item involves the costs of constructing the building that houses the process equipment, utility connections, electricity for the office, site and road preparation materials, and personnel to maintain the facility once it is constructed.

The building costs are based on estimated square footage required for a given treatment system. The building sizes range from 1,000 to 1,500/SF and costs from $34,800 to $44,100. These costs include the prefabricated building and concrete foundation.

Electrical connection costs are estimated at $3,200 for power lines and $16,000 for transformers. Other utility connections, such as water and sewer, are approximately equivalent to the 100 percent of the power line and transformer costs (i.e., $19,200). Office electricity includes the costs of electricity to maintain normal office functions such as lighting at $100/month, 12 months/yr. The site preparation and road costs are based on linear feet (LF) at $23/LF. The amount of road required per treatment facility constructed was assumed to be 100 ft. Labor for the facility includes routine maintenance on the building and utilities at 2 hrs/week.

The in situ biodegradation alternative does not include the cost of a permanent building to house the treatment facility. It does, however, include the same costs for utility connections, electricity, and labor to maintain the pumping and nutrient equipment.

Total facility capital costs range from $22,300 to $84,300. Annual O&M costs range from $3,100 to $4,300.

A3.7.2 Collection System

The Collection System line item involves the cost of influent, effluent, wastewater tanks and pads, pumps, filters, and labor to operate and maintain the equipment.

Influent tanks are sized based on an 8-hour holding time and effluent tanks are sized based on a 4-hour holding time. The tank material and cost is dependent on the tank size. Wastewater tanks are sized based on the amount of wastewater generated by the multimedia filters. Tanks designed for volumes less than 3,000 gallons are fiber reinforced plastic (FRP) and cost up to $4,000; tanks larger than 3,000 gallons are prefabricated of crosslinked polyethylene for increased strength and range in price from $3,000 to $10,000. The tanks are placed on concrete pads that

are 4 ft thick and sized 2 ft larger than the tank diameter. The cost of concrete is estimated at $330/cubic yard (CY).

Also included in this line item are pre- and post-filter feed pumps, a sediment pump, and a filter backwash pump. The capital costs for these pumps range from $690 to $730 for cast iron, totally enclosed, fan-cooled (TEFC) pumps due to their required horsepower. Annual O&M costs include pump replacement every 3 years and the power required to operate the pumps at $0.04/kilowatt hour. The pre- and post-filter feed pumps operate continuously, 24 hrs/day, 330 days/yr. The sediment pump operates for 2 hours, four times per year transferring sediments that collect in the influent tank. The multimedia filter backwash pump operates twice a week for a total of 20 minutes. The annual O&M cost for power and periodic replacement of damaged pumps is estimated to be $1,600.

Multimedia pre-filters are $15,000/filter and bag post-filters are $1,240 for the casing and the initial bag filter. The O&M costs for the bag filters are based on filter replacement every 5 days at $125/25 bags for an annual cost of $330. The disposal costs for the filter solids and bags are based on the costs of using the on-post hazardous waste landfill. The disposal costs for this landfill are 4.07/CY disposed and 9.52/CY of capital charges for landfill use. The volumes of waste generated are based on flow rates, backwash rates, duration, and frequency for the multimedia filter and bag volume and replacement frequency for the bag filter. The disposal costs for the filter solids generated are estimated to be as high as $540 in capital costs and as high as $18,000 in annual O&M costs.

Labor for the collection system involves operation of the tanks, pumps, and filters at 1.5 hrs/day and maintenance at 385 hrs/yr. Annual operations, maintenance, and supervisory labor costs are $16,000. Annual maintenance materials costs are estimated at $5,900.

The costs of Alternative SPC-5 for both in situ biodegradation and treatment at the Basin A/South Plants treatment plant do not follow the aforementioned collection system costs. In situ

biodegradation does not have the same tank, pump, and filtration requirements, and as a result its costs are significantly lower at $5,150 for direct capital and $5,300 for annual O&M costs. The treatment of a 2-gallon per minute (gpm) flow, at the Basin A Neck IRA system involves no additional capital costs, except for the $17 associated with the capital landfill cost. The annual O&M costs for this treatment are also lower at $1,000, and only include filter bag replacement and disposal costs.

Total collection systems capital costs for alternatives other than Alternative SPC-5 range from $29,700 to $55,900 and annual O&M costs range from $33,000 to $45,000.

A3.7.3 Hardness/Iron Pretreatment

The Hardness/Iron Pretreatment line item includes the costs of adding sequesterant to water. Involved in this line item are the costs of the required sequesterant, metering pump, and labor.

The cost of the chemical sequesterant, potassium pyrophosphate, is $4.58 per 30 gallons. It is added to the system at a rate that provides for a concentration in the process stream of 10 micrograms/liter of water treated. The annual pyrophosphate requirement is approximately $5.

The metering pump costs are based on a 0.167-horsepower stainless-steel pump that runs continuously and requires replacement every other year. The capital costs for this pump are $2,600, and the annual O&M costs for pump replacement and power requirement are $790.

The labor involved in adding sequesterant addition includes 1 hr/day for operation and 88 hrs/year for pump maintenance. The annual labor costs are $8,900.

A special case for hardness/iron treatment is Alternative SPC-5, where 2 gpm of water from South Plants is treated at the Basin A Neck IRA system. In this case, only the cost of the extra sequesterant, $1/yr, is included in the annual O&M costs.

The total direct capital costs for hardness/iron treatment are estimated at $2,600. The annual O&M costs for this line item are approximately $9,700.

A3.7.4 Air Stripping Unit

The air stripper, packing replacement, acid wash chemical and tank, pumps, and labor are included in the Air Stripping Unit line item.

The costs of the air stripper towers for the various flow rates are $15,000 for flow rates less than 15 gpm and $17,000 for higher flow rates greater than 15 gpm (Wood 1992). The packing material needs to be replaced once a year and the cost of packing is $19.60/SF. The removed packing material is to be disposed in the on-post hazardous landfill at 4.07/CY. The packing also requires washing with a dilute sulfuric acid solution added to the process stream at a concentration of 100 grams/liter. The cost of acid is $0.18/pound(lb). A day tank is also estimated to provide storage for the acid wash at $600.

The pumps required for this unit are an air stripper feed pump, acid wash metering pump, and an acid recycle pump. The capital cost for these three pumps is $3,000 and annual O&M costs for power usage and periodic pump replacement are $1,000.

Estimated labor time to operate the air stripping unit is 1.25 hours, including operating the air stripper and pumps. Maintenance includes pump maintenance, acid wash, and packing changeout for a total of 225 hours annually. Annual labor costs including operation, maintenance, and supervision are $12,000. Miscellaneous materials used in maintenance amount to approximately $1,430/yr.

Total air stripping unit costs for direct capital range from $18,800 to $20,900. Annual O&M costs for the line item range from $18,000 to $26,000 annually.

A3.7.5 Oxidation

Involved in the Oxidation Unit line item are the oxidation reactor, filter, pumps, and labor to operate and maintain the equipment. Two types of oxidation systems have been considered: ozone/hydrogen peroxide reactors and ultraviolet (UV)/hydrogen peroxide reactors. These oxidation systems have different equipment, labor and cost requirements.

Ozone/hydrogen peroxide oxidation reactors range in cost from $66,000 to $91,000 (Humebaugh 1993). The annual O&M costs to maintain these reactors, including the cost of electricity to operate the ozone generator and cost of hydrogen peroxide feedstock, range from $1,500 to $11,700 depending upon the contaminant concentrations, flow rates, and reactor retention time. These reactors are less labor intensive than UV-based systems.

UV/hydrogen peroxide reactor capital costs range from $150,000 to $250,000 for the reactor and UV lamps depending on the flow rate and residence time (Olson 1993). The annual O&M costs to maintain these reactors, including hydrogen peroxide feedstock, electricity for the UV lamps, and UV lamp replacement, are $58,000.

The pumps required for the oxidation units are a hydrogen peroxide metering pump, a post-oxidation filter feed pump, and a filter backwash pump. The maximum capital and annual O&M pump costs for this line item are $4,000 and $1,500, respectively. The capital costs for the multimedia filter for these units are $15,000. The disposal costs for filter solids are based on the annual costs of disposal in the on-post hazardous waste landfill at 4.07/CY.

Both of the reactor types require 1.5 hours of operating labor daily. The ozone/hydrogen peroxide reactor requires 1 hour of maintenance labor for every 30,000 gallons treated, while the UV/hydrogen peroxide reactor requires twice as much maintenance. The annual O&M costs for labor (operations, maintenance, and supervisory labor and associated maintenance materials) range from $20,000 to $31,000 for the ozone/hydrogen peroxide reactor and from $20,000 to $21,000 for the UV/hydrogen peroxide reactors.

The total direct capital costs of the ozone/hydrogen peroxide reactor unit range from $85,000 to $110,000 and from $150,00 to $267,000 for the UV/hydrogen peroxide unit. The annual O&M costs range from $25,000 to $50,000 for the ozone/hydrogen peroxide unit and from $53,000 to $83,000 for UV/hydrogen peroxide unit.

A3.7.6 Emission Treatment Unit

The Emissions Treatment Unit line item contains an emissions treatment unit (catalytic oxidation reactor or vapor-phase granular activated carbon (GAC) adsorber), air monitoring costs, and labor to operate and maintain the unit.

In all alternatives (except Alternatives SPC-6/SPT-3/SPT-5 and SPC-7/SPT-3/SPT-5) requiring emissions treatment, catalytic oxidation is used to remove and destroy contaminants found in the vapor-phase emissions. Catalytic oxidation capital costs range from $46,000 to $54,000. Annual O&M costs for these units include costs of power for both the blower and auxiliary heat and range from $1,300 to $2,300.

Vapor-phase carbon adsorbers have significantly lower capital costs at $2,900 than catalytic oxidation units. The spent carbon used in these adsorbers must be thermally regenerated at an annual cost of $2,600 for Alternatives SPC-6/SPC-3/SPT-5 and SPC-7/SPC-3/SPT-5.

Air monitoring costs include both weekly and monthly samples of off-gas emissions. The monthly sampling is more comprehensive than the weekly sampling. The annual O&M costs of monitoring are $22,900.

Labor requirements to operate the air treatment unit and to monitor the emissions are estimated at 0.9 hr/day. Maintenance labor requirements for this equipment are 0.25 hr/day for routine catalytic oxidation or GAC maintenance and 4 hrs/yr for replacement of GAC or catalyst. The annual O&M labor costs for emissions treatment total $8,300.

Total capital costs for air treatment with a catalytic oxidation unit range from $46,900 to $54,400; those for vapor-phase GAC adsorption are $2,900. The annual O&M costs for catalytic oxidation units range from $32,500 to $34,000. The annual O&M costs for vapor-phase GAC adsorption are $33,900.

A3.7.7 GAC Adsorption Unit

This GAC Adsorption Unit line item includes the GAC adsorbers, GAC replacement, pumps, GAC tanks, backwash filter, and labor to operate and maintain the units.

The GAC adsorber, designed to treat 10 to 30 gpm, costs $55,000. The cost of regenerating and replacing the spent carbon varies from $190 to $40,000 depending upon the usage requirement for a given system. The cost of regenerating the carbon is estimated at $1.25/lb of carbon (Wood 1992).

The GAC adsorption unit requires a feed and a backwash pump with a total capital cost of $1,500. Annual O&M costs for pump power and periodic replacement are $860 per year.

A bag filter is necessary to remove suspended carbon found in the GAC effluent. The capital cost of a bag filter is $1,200 and the annual O&M costs are $79 based on a replacement frequency of every 5 days. The disposal costs for the bag filter and suspended solids are based on the costs of disposal in the on-post hazardous waste landfill (Section B3.8.2).

The O&M costs associated with treating a 2-gpm flow from Alternative SPC-5 with the Basin A groundwater in the Basin A/South Plants combined treatment plant are $6,900/yr based on the additional GAC usage.

The total capital costs for the GAC adsorption units range from $57,000 to $60,000 and the annual O&M costs range from $6,500 to $64,000.

A3.7.8 LNAPL Disposal

The disposal costs for light nonaqueous phase liquid (LNAPL) included in this line item are the costs of drums, transportation to thermal treatment unit, off-post incineration, and labor.

The cost of steel drums for storage of the LNAPL prior to and during transportation were estimated at $100/drum. It was estimated that approximately 10 drums of LNAPL are to be recovered per year. Also included in the costs is a concrete pad to hold the drums at $2,300. Transportation of these drums to disposal sites off post costs $85/drum. The drums are incinerated as fuel at $150/drum (Brown 1993).

Direct capital LNAPL costs amount to $3,500 and annual O&M costs for the 5 years that LNAPL is to be extracted are $2,900.

A3.7.9 Additional Loading on North Boundary Systems

The costs of additional loading on the NBCS, Basin A Neck IRA, and Basin F Groundwater IRA are included in the Additional Loading line item.

The additional NBCS Loading line item for Alternative NC-3/NT-3 is calculated considering the additional flow rate and concentrations at the NBCS. The costs of this line item were found to be negligible and considered to be zero.

The additional Basin A Neck and Basin F Groundwater IRA Loading line item for Alternative NC-3/NT-3 includes the additional costs involved in an increase in GAC usage at these IRA systems. The annual O&M costs for the additional loading are $9,400 and $1,600, respectively.

A3.7.10 In Situ Biodegradation Unit

The costs involved in the In Situ Biodegradation line item are the costs of nutrients, hydrogen peroxide, pumps, and labor.

Annual O&M costs associated with nutrient and hydrogen peroxide consumption are $1,500. The costs of the pumps used for the addition of the nutrients and hydrogen peroxide to the system are $5,200 for direct capital and $1,400/yr for pump power and replacement. Operating labor for this item consists of 0.5 hr/day for pump operation. The yearly requirement for maintenance labor for this alternative is 176 hours. The total annual labor costs are $8,900. In situ biodegradation capital costs are estimated at $5,200 and annual O&M costs are $12,000.

A3.7.11 Direct Biological Treatment Unit

The items included in the Direct Biological Treatment Unit line item are the biological reactor, filter press, filter, tanks, pumps, additional GAC usage at the Basin A/South Plants combined treatment plant, and labor.

The cost for the biological reactor designed for this application is estimated at $96,000 (Hansen 1992). The annual O&M costs involved in operation of this reactor, including GAC, nutrients and oxygen addition, are $900. The biomass produced by this reactor is removed by a multimedia filter and dewatered in a filter press with a capital cost of $15,000 and $23,000, respectively. The annual power cost to operate the filter press is $1,200. The solids from the filter press are disposed in the on-post hazardous waste landfill at 4.07 CY for a total annual O&M cost of $2,600.

The tanks required for this unit (influent, effluent, and thickener tanks) are constructed of fiberglass, with a total capital cost of $23,000. The tanks are installed on pads that are estimated to cost $5,700 each.

The pumps required to operate this system are bioreactor feed and recycle pumps, post-filter feed pumps, sediment pump, and filter backwash pump. The capital cost for these pumps is $6,300 and annual O&M costs for pump power and replacement are $3,200.

Additional GAC usage for the adsorbers was estimated at 2,800 lbs/yr or $3,500 annually.

Operating labor requirements for this unit was estimated at 2 hrs/day and maintenance labor at 350 hrs/yr for an annual labor cost, including supervision and associated maintenance materials, at $24,000.

Capital costs for the direct biological treatment unit are estimated at $126,000. Annual O&M costs for this system are $35,000.

A3.7.12 Balance of Capital

The Balance of Capital line item includes the cost of additional capital items that were not part of any specific treatment unit. These costs were estimated as percentages of the direct capital treatment equipment costs. Balance of capital specifically includes instrumentation (35 percent), freight and handling (6 percent), installation (45 percent), site development (10 percent), electrical (11 percent), and piping and insulation (60 percent).

The capital costs for this line item range from $5,300 to $790,000.

A4.0 INDIRECT COSTS

Indirect costs are applied to the sum of the two main cost groups which include direct capital costs and direct O&M operating costs. The indirect costs include:

- mobilization/demobilization
- indirects, overhead, and profit
- engineering design
- resident engineering
- contingency

The indirect costs vary due to the four consideration factors: medium group contamination; technologies selected; size of the project; and the duration. Based on the characteristics of each alternative as it applied to medium group characteristics, these factors assist in the development

of indirect percentages as explained below. These indirect percentages are then applied to the direct costs to determine an overall total cost.

In order to provide a uniform basis of estimate, a cost markup matrix was developed to determine indirect costs percentages for direct capital and O&M costs and is presented in Table A4.0-1. In some instances, these factors were individually adjusted to be more representative of the individual alternative's complexity. The following sections explain the indirect markup factors and the application rationale.

A4.1 MOBILIZATION/DEMOBILIZATION

Mobilization activities include construction/setup of contractor support facilities, mobilization of heavy equipment, and relocation of management/supervisory personnel. Demobilization consists of decontamination and removal of contractor's equipment and facilities from the site. Costs for these activities are applied as a percentage of direct cost. These percentages applied vary from 2 to 7 percent as shown in the markup matrix.

A4.2 INDIRECTS, OVERHEAD AND PROFIT

Indirect Costs are calculated as a percentage of the sum of direct and mobilization/demobilization costs. Indirect costs cover on-site management, administrative, technical, health and safety, and supervisory staff, utilities for site support facilities (excluding production facilities), engineering tests, QA/QC program, preparation of work plans, submittals and as-built drawings, bonding costs, support facilities, and vehicle maintenance and operation. The range of percentages applied vary between 34 to 44 percent.

A4.3 DESIGN ENGINEERING

The engineering design costs are estimate as a percentage of the sum of direct costs; mobilization/demobilization costs; and indirects, overhead, and profits. In general, engineering percentages were developed based on past experience of engineering costs on similar projects. These percentages are dependent upon the degree of complexity associated with the particularly

alternative and the complexity of the treatment technology selected. Standard percentages ranging between 3 to 6 percent are applied to the estimates, however, certain alternatives required adjustments to reflect extenuating circumstances in the required design effort and were adjust accordingly.

A4.4 RESIDENT ENGINEERING

The resident engineering costs are estimated as a percentage of the sum of direct costs: mobilization/demobilization costs; and indirects, overhead, and profits. Based on the alternative size, estimated project duration, and the remedial technology selected would require thorough, full-time inspection and field engineering support by a multi-member staff to assure conformance and verification with the approved remedial design. Standard percentages ranging between 1 to 3 percent are applied to the estimates.

A4.5 CONTINGENCY

Contingency is applied as a percentage of the sum of direct costs; mobilization/demobilization costs; and indirect, overhead, and profit costs; and design and resident engineering costs. Contingency is a specific provision for unforeseeable costs within the defined project scope; it is particularly important where previous experience relating estimates and actual costs (e.g., complexity of the treatment technology, unforeseen and unpredictable conditions, and/or uncertainties within the scope of this project) has shown that unforeseeable events that increase costs are likely to occur . Other considerations that may affect the selection of contingency are levels of contamination; environmental media and climatic conditions; scheduling; changes in federal, state, or local regulations; and other considerations unique to the project such as waste management permits and regulatory reviews.

Separate contingency costs were developed for capital expenditures and O & M, both of which are illustrated in the markup matrix. A contingency range for this level of detail is typically 20 to 50 percent, which was applied to these estimates. The contingency to be provided for the current estimates was developed based on four cost parameters: the levels of contamination, the

complexity of the treatment technology, the size of the project, and the estimated duration of the activity. The amount of contingency applied to the estimates in this document ranged between 25 to 40 percent based on these consideration factors and on professional experience and knowledge with similar remedial projects.

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Table A1-1 Cost Estimate - Northwest Boundary Plume Group
Alternative NWC-1: No Action

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Cost Item			Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT CAPITAL COSTS											
Slurrywall Demolition			LS	1	--	22,400.00	/EA	1	EA	26,000	26,000
		Subtotal (A)								26,000	26,000
COST CODE LLSS											
INDIRECT CAPITAL COSTS											
Mob/Demob	3.3%	B = 0.033 * (A)								1,000	1,000
Indirects, Overhead & Profit	39.0%	C = 0.390 * (A+B)								10,000	10,000
Engineering Design	3.0%	D = 0.030 * (A+B+C)								1,000	1,000
Resident Engineering	1.3%	E = 0.013 * (A+B+C+D)								0	0
Contingency	26.3%	F = 0.263 * (A+B+C+D)								10,000	10,000
		Subtotal (G =B+C+D+E+F)								23,000	23,000
TOTAL CAPITAL COSTS (H = A+G)										48,000	48,000

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Table A1-1 Cost Estimate - Northwest Boundary Plume Group
Alternative NWC-1: No Action

Cost Item			Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Annual Cost Yr 1-5	1995 ($) Annual Cost Yr 6-10	1995 ($) Annual Cost Yr 11-30	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT O&M COSTS (OPERATIONS)														
Well System & Plume Evaluation Monitoring			A	1	30	17,967.00	/EA-YR	1	EA	20,500	20,500	20,500	615,000	326,000
Subtotal (I)										20,500	20,500	20,500	615,000	326,000
COST CODE LLSL														
INDIRECT O&M COSTS (OPERATIONS)														
Indirects, Overhead & Profit	39.0%	J = 0.390 * (I)								8,000	8,000	8,000	240,000	127,000
Resident Engineering	1.8%	K = 0.018 * (I+J)								0	0	0	15,000	8,000
Contingency	30.0%	L = 0.300 * (I+J+K)								9,000	9,000	9,000	261,000	138,000
Subtotal (O = J+K+L)										17,000	17,000	17,000	516,000	273,000
TOTAL O&M COSTS (T = I+O)										37,500	37,500	37,500	1,131,000	599,000
TOTAL CAPITAL COSTS AND TOTAL O&M COSTS (U = H+T)													1,180,000	648,000

Table A1-2 Cost Estimate - Northwest Boundary Plume Group
Alternative NWC-2: Continued Existing Action

Cost Item			Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT CAPITAL COSTS											
		Subtotal (A)								0	0
COST CODE LLSS											
INDIRECT CAPITAL COSTS											
Mob/Demob	3.3%	B = 0.033 * (A)								0	0
Indirects, Overhead & Profit	39.0%	C = 0.390 * (A+B)								0	0
Engineering Design	3.0%	D = 0.030 * (A+B+C)								0	0
Resident Engineering	1.3%	E = 0.013 * (A+B+C+D)								0	0
Contingency	26.3%	F = 0.263 * (A+B+C+D)								0	0
		Subtotal (G =B+C+D+E+F)								0	0
TOTAL CAPITAL COSTS (H = A+G)										0	0

Table A1-2 Cost Estimate - Northwest Boundary Plume Group
Alternative NWC-2: Continued Existing Action

Cost Item	Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Annual Cost Yr 1-5	Yr 6-10	Yr 11-30	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT O&M COSTS (OPERATIONS)												
Continued Operation of NWBCS	A	1	30	578,600.00	/EA-YR	1	EA	660,000	660,000	660,000	19,808,000	10,497,000
Well System & Plume Evaluation Monitoring	A	1	30	17,967.00	/EA-YR	1	EA	21,000	21,000	21,000	615,000	326,000
Subtotal (I)								681,000	681,000	681,000	20,423,000	10,823,000
COST CODE LMSL												
INDIRECT O&M COSTS (OPERATIONS)												
Indirects, Overhead & Profit 39.0% J = 0.390 * (I)								266,000	266,000	266,000	7,965,000	4,221,000
Resident Engineering 2.0% K = 0.020 * (I+J)								19,000	19,000	19,000	568,000	301,000
Contingency 31.3% L = 0.313 * (I+J+K)								302,000	302,000	302,000	9,049,000	4,795,000
Subtotal (O = J+K+L)								587,000	587,000	587,000	17,582,000	9,317,000
TOTAL O&M COSTS (T = I+O)								1,268,000	1,268,000	1,268,000	38,005,000	20,140,000
TOTAL CAPITAL COSTS AND TOTAL O&M COSTS (U = H+T)											38,000,000	20,100,000

Table A2-1 Cost Estimate - Western Plume Group
Alternative WC-1: No Action

Cost Item			Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT CAPITAL COSTS											
		Subtotal (A)								0	0
COST CODE LLSS											
INDIRECT CAPITAL COSTS											
Mob/Demob	3.3%	B = 0.033 * (A)								0	0
Indirects, Overhead & Profit	39.0%	C = 0.390 * (A+B)								0	0
Engineering Design	3.0%	D = 0.030 * (A+B+C)								0	0
Resident Engineering	1.3%	E = 0.013 * (A+B+C+D)								0	0
Contingency	26.3%	F = 0.263 * (A+B+C+D)								0	0
		Subtotal (G =B+C+D+E+F)								0	0
TOTAL CAPITAL COSTS (H = A+G)										0	0

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Table A2-1 Cost Estimate - Western Plume Group
Alternative WC-1: No Action

Cost Item			Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Annual Cost Yr 1-5	1995 ($) Annual Cost Yr 6-10	1995 ($) Annual Cost Yr 11-30	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT O&M COSTS (OPERATIONS)														
Well System & Plume Evaluation Monitoring			A	1	30	27,593.00	/EA-YR	1	EA	31500	31,500	31,500	945,000	501,000
		Subtotal (I)								31,500	31,500	31,500	945,000	501,000
COST CODE LLSL														
INDIRECT O&M COSTS (OPERATIONS)														
Indirects, Overhead & Profit	39.0%	J = 0.390 * (I)								12,000	12,000	12,000	368,000	195,000
Resident Engineering	1.8%	K = 0.018 * (I+J)								1,000	1,000	1,000	23,000	12,000
Contingency	30.0%	L = 0.300 * (I+J+K)								13,000	13,000	13,000	401,000	212,000
		Subtotal (O = J+K+L)								26,000	26,000	26,000	792,000	420,000
TOTAL O&M COSTS (T = I+O)										57,500	57,500	57,500	1,737,000	920,000
TOTAL CAPITAL COSTS AND TOTAL O&M COSTS (U = II+T)													1,740,000	920,000

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Table A2-2 Cost Estimate - Western Plume Group
Alternative WC-2: Continued Existing Action

Cost Item			Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT CAPITAL COSTS											
		Subtotal (A)								0	0
COST CODE LLSS											
INDIRECT CAPITAL COSTS											
Mob/Demob	3.3%	B = 0.033 * (A)								0	0
Indirects, Overhead & Profit	39.0%	C = 0.390 * (A+B)								0	0
Engineering Design	3.0%	D = 0.030 * (A+B+C)								0	0
Resident Engineering	1.3%	E = 0.013 * (A+B+C+D)								0	0
Contingency	26.3%	F = 0.263 * (A+B+C+D)								0	0
		Subtotal (G =B+C+D+E+F)								0	0
TOTAL CAPITAL COSTS (H = A+G)										0	0

Table A2-2 Cost Estimate - Western Plume Group
Alternative WC-2: Continued Existing Action

Cost Item			Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Annual Cost Yr 1-5	1995 ($) Annual Cost Yr 6-10	1995 ($) Annual Cost Yr 11-30	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT O&M COSTS (OPERATIONS)														
Continued Operation of ICS			A	1	30	401,600.00	/EA-YR	1	EA	458,000	458,000	458,000	13,749,000	7,286,000
Well System & Plume Evaluation Monitoring			A	1	30	27,593.00	/EA-YR	1	EA	31,000	31,000	31,000	945,000	501,000
		Subtotal (I)								489,000	489,000	489,000	14,693,000	7,787,000
COST CODE LMSL														
INDIRECT O&M COSTS (OPERATIONS)														
Indirects, Overhead & Profit	39.0%	J = 0.390 * (I)								191,000	191,000	191,000	5,730,000	3,037,000
Resident Engineering	2.0%	K = 0.020 * (I+J)								14,000	14,000	14,000	408,000	216,000
Contingency	31.3%	L = 0.313 * (I+J+K)								217,000	217,000	217,000	6,510,000	3,450,000
		Subtotal (O = J+K+L)								422,000	422,000	422,000	12,649,000	6,703,000
TOTAL O&M COSTS (T = I+O)										911,000	911,000	911,000	27,342,000	14,490,000
TOTAL CAPITAL COSTS AND TOTAL O&M COSTS (U = H+T)													27,300,000	14,500,000

Table A3-1 Cost Estimate - North Boundary Plume Group
Alternative NC-1: No Action

Cost Item			Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT CAPITAL COSTS											
Slurrywall Demolition			LS	1	--	76,980.00	/EA	1	EA	88,000	88,000
		Subtotal (A)								88,000	88,000
COST CODE LLSS											
INDIRECT CAPITAL COSTS											
Mob/Demob	3.3%	B = 0.033 * (A)								3,000	3,000
Indirects, Overhead & Profit	39.0%	C = 0.390 * (A+B)								35,000	35,000
Engineering Design	3.0%	D = 0.030 * (A+B+C)								4,000	4,000
Resident Engineering	1.3%	E = 0.013 * (A+B+C+D)								2,000	2,000
Contingency	26.3%	F = 0.263 * (A+B+C+D)								34,000	34,000
		Subtotal (G =B+C+D+E+F)								78,000	78,000
TOTAL CAPITAL COSTS (H = A+G)										166,000	166,000

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Table A3-1 Cost Estimate - North Boundary Plume Group
Alternative NC-1: No Action

Cost Item			Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Annual Cost Yr 1-5	1995 ($) Annual Cost Yr 6-10	1995 ($) Annual Cost Yr 11-30	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT O&M COSTS (OPERATIONS)														
Well System & Plume Evaluation Monitoring			A	1	30	35,934.00	/EA-YR	1	EA	41,000	41,000	41,000	1,230,000	652,000
		Subtotal (I)								41,000	41,000	41,000	1,230,000	652,000
COST CODE LLSL														
INDIRECT O&M COSTS (OPERATIONS)														
Indirects, Overhead & Profit	39.0%	J = 0.390 * (I)								16,000	16,000	16,000	480,000	254,000
Resident Engineering	1.8%	K = 0.018 * (I+J)								1,000	1,000	1,000	30,000	16,000
Contingency	30.0%	L = 0.300 * (I+J+K)								17,000	17,000	17,000	522,000	277,000
		Subtotal (O = J+K+L)								34,000	34,000	34,000	1,032,000	547,000
TOTAL O&M COSTS (T = I+O)										75,000	75,000	75,000	2,262,000	1,199,000
TOTAL CAPITAL COSTS AND TOTAL O&M COSTS (U = H+T)													2,430,000	1,360,000

Table A3-2 Cost Estimate - North Boundary Plume Group
Alternative NC-2: Continued Existing Action

Cost Item			Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT CAPITAL COSTS											
		Subtotal (A)								0	0
COST CODE LLSS											
INDIRECT CAPITAL COSTS											
Mob/Demob	3.3%	B = 0.033 * (A)								0	0
Indirects, Overhead & Profit	39.0%	C = 0.390 * (A+B)								0	0
Engineering Design	3.0%	D = 0.030 * (A+B+C)								0	0
Resident Engineering	1.3%	E = 0.013 * (A+B+C+D)								0	0
Contingency	26.3%	F = 0.263 * (A+B+C+D)								0	0
		Subtotal (G =B+C+D+E+F)								0	0
TOTAL CAPITAL COSTS (H = A+G)										0	0

Table A3-2 Cost Estimate - North Boundary Plume Group
Alternative NC-2: Continued Existing Action

Cost Item	Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Annual Cost Yr 1-5	Yr 6-10	Yr 11-30	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT O&M COSTS (OPERATIONS)												
Continued Operation of NBCS	A	1	30	1,185,000.00	/EA-YR	1	EA	1,352,000	1,352,000	1,352,000	40,568,000	21,499,000
Well System & Plume Evaluation Monitoring	A	1	30	35,934.00	/EA-YR	1	EA	41,000	41,000	41,000	1,230,000	652,000
Subtotal (I)								1,393,000	1,393,000	1,393,000	41,799,000	22,151,000
COST CODE LMSL												
INDIRECT O&M COSTS (OPERATIONS)												
Indirects, Overhead & Profit 39.0% J = 0.390 * (I)								543,000	543,000	543,000	16,301,000	8,639,000
Resident Engineering 2.0% K = 0.020 * (I+J)								39,000	39,000	39,000	1,162,000	616,000
Contingency 31.3% L = 0.313 * (I+J+K)								617,000	617,000	617,000	18,519,000	9,814,000
Subtotal (O = J+K+L)								1,199,000	1,199,000	1,199,000	35,983,000	19,069,000
TOTAL O&M COSTS (T = I+O)								2,592,000	2,592,000	2,592,000	77,782,000	41,219,000
TOTAL CAPITAL COSTS AND TOTAL O&M COSTS (U = H+T)											77,800,000	41,200,000

Table A3-3 **Cost Estimate - North Boundary Plume Group**
Alternative NC-3/NT-2: Interception, Treatment at NBCS

Cost Item			Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT CAPITAL COSTS											
Extraction Wells & Pump Installation			LS	1	--	128,507.00	/EA	1	EA	147,000	147,000
Performance Monitoring Well Installation			LS	1	--	84,910.00	/EA	1	EA	97,000	97,000
Extraction Pipe & System Installation			LS	1	--	131,311.00	/EA	1	EA	150,000	150,000
		Subtotal (A)								393,000	393,000
COST CODE MLSS											
INDIRECT CAPITAL COSTS											
Mob/Demob	3.9%	B = 0.039 • (A)								15,000	15,000
Indirects, Overhead & Profit	40.3%	C = 0.403 • (A+B)								164,000	164,000
Engineering Design	3.0%	D = 0.030 • (A+B+C)								17,000	17,000
Resident Engineering	1.5%	E = 0.015 • (A+B+C+D)								9,000	9,000
Contingency	27.5%	F = 0.275 • (A+B+C+D)								162,000	162,000
		Subtotal (G =B+C+D+E+F)								368,000	368,000
TOTAL CAPITAL COSTS (H = A+G)										761,000	761,000

Table A3-3 **Cost Estimate - North Boundary Plume Group**

Alternative NC-3/NT-2: Interception, Treatment at NBCS

Cost Item			Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1993 ($) Annual Cost Yr 1-5	1993 ($) Annual Cost Yr 6-10	1993 ($) Annual Cost Yr 11-30	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT O&M COSTS (OPERATIONS)														
Maintenance & Repair			A	1	30	28,362.00	/EA-YR	1	EA	32,000	32,000	32,000	971,000	515,000
Well & Pump Operations			A	1	30	822.00	/EA-YR	1	EA	1,000	1,000	1,000	28,000	15,000
Well System & Plume Evaluation Monitoring			A	1	30	62,877.00	/EA-YR	1	EA	72,000	72,000	72,000	2,153,000	1,141,000
Continued Operation of NBCS			A	1	30	1,185,000.00	/EA-YR	1	EA	1,352,000	1,352,000	1,352,000	40,568,000	21,499,000
Additional NBCS Loading			A	1	30	38.75	/EA-YR	1	EA	40	40	40	1,000	1,000
		Subtotal (I)								1,457,040	1,457,040	1,457,040	43,721,000	23,170,000
COST CODE LMSL														
INDIRECT O&M COSTS (OPERATIONS)														
Indirects, Overhead & Profit	39.0%	J = 0.390 * (I)								568,000	568,000	568,000	17,051,000	9,036,000
Resident Engineering	2.0%	K = 0.020 * (I+J)								41,000	41,000	41,000	1,215,000	644,000
Contingency	31.3%	L = 0.313 * (I+J+K)								646,000	646,000	646,000	19,371,000	10,266,000
		Subtotal (O = J+K+L)								1,255,000	1,255,000	1,255,000	37,638,000	19,946,000
TOTAL O&M COSTS (T = I+O)										2,712,000	2,712,000	2,712,000	81,360,000	43,116,000
TOTAL CAPITAL COSTS AND TOTAL O&M COSTS (U = H+T)													82,100,000	43,900,000

Table A3-4 Cost Estimate - North Boundary Plume Group
Alternative NC-3/NT-3: Interception, Treatment at Basin A Neck IRA

Cost Item			Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT CAPITAL COSTS											
Extraction Wells & Pump Installation			LS	1	--	128,507.00	/EA	1	EA	147,000	147,000
Performance Monitoring Well Installation			LS	1	--	84,910.00	/EA	1	EA	97,000	97,000
Extraction Pipe & System Installation			LS	1	--	166,475.00	/EA	1	EA	190,000	190,000
		Subtotal (A)								434,000	434,000
COST CODE MMSS											
INDIRECT CAPITAL COSTS											
Mob/Demob	4.5%	B = 0.045 * (A)								20,000	20,000
Indirects, Overhead & Profit	40.3%	C = 0.403 * (A+B)								182,000	182,000
Engineering Design	4.5%	D = 0.045 * (A+B+C)								29,000	29,000
Resident Engineering	1.8%	E = 0.018 * (A+B+C+D)								12,000	12,000
Contingency	28.8%	F = 0.288 * (A+B+C+D)								191,000	191,000
		Subtotal (G =B+C+D+E+F)								433,000	433,000
TOTAL CAPITAL COSTS (H = A+G)										866,000	866,000

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Table A3-4 Cost Estimate - North Boundary Plume Group
Alternative NC-3/NT-3: Interception, Treatment at Basin A Neck IRA

Cost Item	Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Annual Cost Yr 1-5	1995 ($) Annual Cost Yr 6-10	1995 ($) Annual Cost Yr 11-30	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT O&M COSTS (OPERATIONS)												
Maintenance & Repair	A	1	30	28,362.00	/EA-YR	1	EA	32,000	32,000	32,000	971,000	515,000
Well & Pump Operations	A	1	30	822.00	/EA-YR	1	EA	1,000	1,000	1,000	28,000	15,000
Well System & Plume Evaluation Monitoring	A	1	30	62,877.00	/EA-YR	1	EA	72,000	72,000	72,000	2,153,000	1,141,000
Continued Operation of NBCS	A	1	30	1,185,000.00	/EA-YR	1	EA	1,352,000	1,352,000	1,352,000	40,568,000	21,499,000
Additional Basin F IRA Loading	A	1	30	9,375.00	/EA-YR	1	EA	11,000	11,000	11,000	321,000	170,000
Additional Basin A IRA Loading	A	1	30	1,625.00	/EA-YR	1	EA	2,000	2,000	2,000	56,000	29,000
Subtotal (I)								1,470,000	1,470,000	1,470,000	44,097,000	23,369,000
COST CODE LMSL												
INDIRECT O&M COSTS (OPERATIONS)												
Indirects, Overhead & Profit 39.0% J = 0.390 * (I)								573,000	573,000	573,000	17,198,000	9,114,000
Resident Engineering 2.0% K = 0.020 * (I+J)								41,000	41,000	41,000	1,226,000	650,000
Contingency 31.3% L = 0.313 * (I+J+K)								651,000	651,000	651,000	19,538,000	10,354,000
Subtotal (O = J+K+L)								1,265,000	1,265,000	1,265,000	37,961,000	20,117,000
TOTAL O&M COSTS (T = I+O)								2,735,000	2,735,000	2,735,000	82,058,000	43,486,000
TOTAL CAPITAL COSTS AND TOTAL O&M COSTS (U = H+T)											82,900,000	44,400,000

Table A3-5 Cost Estimate - North Boundary Plume Group
Alternative NC-3/NT-4: Interception, Oxidation

Cost Item			Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT CAPITAL COSTS											
Control System											
Extraction Wells & Pump Installation			LS	1	--	128,507.00	/EA	1	EA	147,000	147,000
Performance Monitoring Well Installation			LS	1	--	84,910.00	/EA	1	EA	97,000	97,000
Extraction Pipe & System Installation			LS	1	--	166,475.00	/EA	1	EA	190,000	190,000
Treatment System											
Balance of Capital Costs, Treatment			LS	1	--	265,475.00	/EA	1	EA	303,000	303,000
Oxidation Unit			LS	1	--	169,092.00	/EA	1	EA	193,000	193,000
		Subtotal (A)								929,000	929,000
COST CODE MMSS											
INDIRECT CAPITAL COSTS											
Mob/Demob	4.5%	B = 0.045 * (A)								42,000	42,000
Indirects, Overhead & Profit	40.3%	C = 0.403 * (A+B)								391,000	391,000
Engineering Design	4.5%	D = 0.045 * (A+B+C)								61,000	61,000
Resident Engineering	1.8%	E = 0.018 * (A+B+C+D)								25,000	25,000
Contingency	28.8%	F = 0.288 * (A+B+C+D)								409,000	409,000
		Subtotal (G =B+C+D+E+F)								928,000	928,000
TOTAL CAPITAL COSTS (H = A+G)										1,858,000	1,858,000

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Table A3-5 Cost Estimate - North Boundary Plume Group
Alternative NC-3/NT-4: Interception, Oxidation

Cost Item	Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Annual Cost Yr 1-5	Yr 6-10	Yr 11-30	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT O&M COSTS (OPERATIONS)												
Control System												
Maintenance & Repair	A	1	30	28,362.00	/EA-YR	1	EA	32,000	32,000	32,000	971,000	515,000
Well & Pump Operations	A	1	30	822.00	/EA-YR	1	EA	1,000	1,000	1,000	28,000	15,000
Well System & Plume Evaluation Monitoring	A	1	30	62,877.00	/EA-YR	1	EA	72,000	72,000	72,000	2,153,000	1,141,000
Treatment System												
Continued Operation of NBCS	A	1	30	1,185,000.00	/EA-YR	1	EA	1,352,000	1,352,000	1,352,000	40,568,000	21,499,000
Oxidation Unit	A	1	30	52,654.00	/EA-YR	1	EA	60,000	60,000	60,000	1,803,000	955,000
Subtotal (I)								1,517,000	1,517,000	1,517,000	45,523,000	24,124,000
COST CODE LMSL												
INDIRECT O&M COSTS (OPERATIONS)												
Indirects, Overhead & Profit 39.0% J = 0.390 * (I)								592,000	592,000	592,000	17,754,000	9,408,000
Resident Engineering 2.0% K = 0.020 * (I+J)								42,000	42,000	42,000	1,266,000	671,000
Contingency 31.3% L = 0.313 * (I+J+K)								672,000	672,000	672,000	20,169,000	10,689,000
Subtotal (O = J+K+L)								1,306,000	1,306,000	1,306,000	39,189,000	20,768,000
TOTAL O&M COSTS (T = I+O)								2,823,000	2,823,000	2,823,000	84,712,000	44,892,000
TOTAL CAPITAL COSTS AND TOTAL O&M COSTS (U = H+T)											86,600,000	46,700,000

Table A3-6 Cost Estimate - North Boundary Plume Group
Alternative NC-6: Clay/Soil Cap

Cost Item			Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT CAPITAL COSTS											
Soil Capping			LS	1	--	23,203,339.00	/EA	1	EA	26,479,000	26,479,000
		Subtotal (A)								26,479,000	26,479,000
COST CODE LLMS											
INDIRECT CAPITAL COSTS											
Mob/Demob	3.3%	B = 0.033 * (A)								861,000	861,000
Indirects, Overhead & Profit	37.8%	C = 0.378 * (A+B)								10,321,000	10,321,000
Engineering Design	3.0%	D = 0.030 * (A+B+C)								1,130,000	1,130,000
Resident Engineering	1.3%	E = 0.013 * (A+B+C+D)								485,000	485,000
Contingency	26.3%	F = 0.263 * (A+B+C+D)								10,182,000	10,182,000
		Subtotal (G =B+C+D+E+F)								22,978,000	22,978,000
TOTAL CAPITAL COSTS (H = A+G)										49,457,000	49,457,000

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Table A3-6 Cost Estimate - North Boundary Plume Group
Alternative NC-6: Clay/Soil Cap

Cost Item			Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Annual Cost Yr 1-5	1995 ($) Annual Cost Yr 6-10	1995 ($) Annual Cost Yr 11-30	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT O&M COSTS (OPERATIONS)														
Well System & Plume Evaluation Monitoring			A	1	30	35,934.00	/EA-YR	1	EA	41,000	41,000	41,000	1,230,000	652,000
Continued Operation of NBCS			A	1	30	1,185,000.00	/EA-YR	1	EA	1,352,000	1,352,000	1,352,000	40,568,000	21,499,000
Soil Capping			A	1	30	3,872.00	/EA-YR	1	EA	4,000	4,000	4,000	133,000	70,000
		Subtotal (I)								1,397,000	1,397,000	1,397,000	41,931,000	22,221,000
COST CODE LMSL														
INDIRECT O&M COSTS (OPERATIONS)														
Indirects, Overhead & Profit	39.0%	J = 0.390 * (I)								545,000	545,000	545,000	16,353,000	8,666,000
Resident Engineering	2.0%	K = 0.020 * (I+J)								39,000	39,000	39,000	1,166,000	618,000
Contingency	31.3%	L = 0.313 * (I+J+K)								619,000	619,000	619,000	18,578,000	9,845,000
		Subtotal (O = J+K+L)								1,203,000	1,203,000	1,203,000	36,097,000	19,129,000
TOTAL O&M COSTS (T = I+O)										2,600,000	2,600,000	2,600,000	78,028,000	41,350,000
TOTAL CAPITAL COSTS AND TOTAL O&M COSTS (U = H+T)													127,000,000	90,800,000

Table A4-1 Cost Estimate - Basin A Plume Group
Alternative AC-1: No Action

Cost Item			Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT CAPITAL COSTS											
Slurrywall Demolition			LS	1	--	14,940.00	/EA	1	EA	17,000	17,000
		Subtotal (A)								17,000	17,000
COST CODE LLSS											
INDIRECT CAPITAL COSTS											
Mob/Demob	3.3%	B = 0.033 * (A)								600	600
Indirects, Overhead & Profit	39.0%	C = 0.390 * (A+B)								6,900	6,900
Engineering Design	3.0%	D = 0.030 * (A+B+C)								700	700
Resident Engineering	1.3%	E = 0.013 * (A+B+C+D)								300	300
Contingency	26.3%	F = 0.263 * (A+B+C+D)								6,600	6,600
		Subtotal (G =B+C+D+E+F)								15,100	15,100
TOTAL CAPITAL COSTS (H = A+G)										32,100	32,100

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Table A4-1 Cost Estimate - Basin A Plume Group
Alternative AC-1: No Action

			Cost	Start	End	1992 ($)				1995 ($) Annual Cost			1995 ($)	1995 ($)
Cost Item			Type	Year	Year	Unit Cost	Units	Quantity	Units	Yr 1-5	Yr 6-10	Yr 11-30	Total Cost	PW Cost
DIRECT O&M COSTS (OPERATIONS)														
Well System & Plume Evaluation Monitoring			A	1	30	44,917.00	/EA-YR	1	EA	51,300	51,300	51,300	1,538,000	815,000
		Subtotal (I)								51,300	51,300	51,300	1,538,000	815,000
COST CODE LLSL														
INDIRECT O&M COSTS (OPERATIONS)														
Indirects, Overhead & Profit	39.0%	J = 0.390 * (I)								20,000	20,000	20,000	600,000	318,000
Resident Engineering	1.8%	K = 0.018 * (I+J)								1,000	1,000	1,000	37,000	20,000
Contingency	30.0%	L = 0.300 * (I+J+K)								22,000	22,000	22,000	652,000	346,000
		Subtotal (O = J+K+L)								43,000	43,000	43,000	1,290,000	683,000
TOTAL O&M COSTS (T = I+O)										94,300	94,300	94,300	2,827,000	1,498,000
TOTAL CAPITAL COSTS AND TOTAL O&M COSTS (U = H+T)													2,860,000	1,530,000

Table A4-2 Cost Estimate - Basin A Plume Group
Alternative AC-2: Continued Existing Action

Cost Item			Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT CAPITAL COSTS											
		Subtotal (A)								0	0
COST CODE LLSS											
INDIRECT CAPITAL COSTS											
Mob/Demob	3.3%	B = 0.033 * (A)								0	0
Indirects, Overhead & Profit	39.0%	C = 0.390 * (A+B)								0	0
Engineering Design	3.0%	D = 0.030 * (A+B+C)								0	0
Resident Engineering	1.3%	E = 0.013 * (A+B+C+D)								0	0
Contingency	26.3%	F = 0.263 * (A+B+C+D)								0	0
		Subtotal (G =B+C+D+E+F)								0	0
TOTAL CAPITAL COSTS (H = A+G)										0	0

Table A4-2 Cost Estimate - Basin A Plume Group
Alternative AC-2: Continued Existing Action

Cost Item			Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Annual Cost Yr 1-5	1995 ($) Annual Cost Yr 6-10	1995 ($) Annual Cost Yr 11-30	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT O&M COSTS (OPERATIONS)														
Continued Operation of Basin A Neck IRA			A	1	30	478,000.00	/EA-YR	1	EA	545,000	545,000	545,000	16,364,000	8,672,000
Well System & Plume Evaluation Monitoring			A	1	30	44,917.00	/EA-YR	1	EA	51,000	51,000	51,000	1,538,000	815,000
Subtotal (I)										596,000	596,000	596,000	17,902,000	9,487,000
COST CODE LMSL														
INDIRECT O&M COSTS (OPERATIONS)														
Indirects, Overhead & Profit	39.0%	J = 0.390 * (I)								232,000	232,000	232,000	6,982,000	3,700,000
Resident Engineering	2.0%	K = 0.020 * (I+J)								17,000	17,000	17,000	498,000	264,000
Contingency	31.3%	L = 0.313 * (I+J+K)								264,000	264,000	264,000	7,932,000	4,203,000
Subtotal (O = J+K+L)										513,000	513,000	513,000	15,411,000	8,167,000
TOTAL O&M COSTS (T = I+O)										1,109,000	1,109,000	1,109,000	33,313,000	17,654,000
TOTAL CAPITAL COSTS AND TOTAL O&M COSTS (U = H+T)													33,300,000	17,700,000

Table A4-3 Cost Estimate - Basin A Plume Group
Alternative AC-3/AT-2: Mass Reduction, Air Stripping/GAC Adsorption

Cost Item	Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT CAPITAL COSTS									
Control System									
Extraction Wells & Pump Installation	LS	1	--	596,112.00	/EA	1	EA	680,000	680,000
Performance Monitoring Well Installation	LS	1	--	411,805.00	/EA	1	EA	470,000	470,000
Extraction Pipe & System Installation	LS	1	--	557,235.00	/EA	1	EA	636,000	636,000
Reinjection Pipe & System Installation	LS	1	--	201,664.00	/EA	1	EA	230,000	230,000
Recharge Trench Installation	LS	1	--	174,000.00	/EA	1	EA	199,000	199,000
Treatment System									
Balance of Capital Costs, Treatment	LS	1	--	274,791.00	/EA	1	EA	314,000	314,000
Treatment Facility, 1000 Square Feet	LS	1	--	75,062.00	/EA	1	EA	86,000	86,000
Collection System	LS	1	--	38,683.00	/EA	1	EA	44,000	44,000
Hardness/Iron Treatment Unit	LS	1	--	2,600.00	/EA	1	EA	3,000	3,000
Air Stripping Unit	LS	1	--	18,881.00	/EA	1	EA	22,000	22,000
Emissions Treatment Unit	LS	1	--	46,900.00	/EA	1	EA	54,000	54,000
Granular Activated Carbon Adsorption Unit	LS	1	--	57,481.00	/EA	1	EA	66,000	66,000
Subtotal (A)								2,802,000	2,802,000
COST CODE HMSS									
INDIRECT CAPITAL COSTS									
Mob/Demob	5.1%	B = 0.051 * (A)						144,000	144,000
Indirects, Overhead & Profit	41.5%	C = 0.415 * (A+B)						1,222,000	1,222,000
Engineering Design	4.5%	D = 0.045 * (A+B+C)						188,000	188,000
Resident Engineering	2.0%	E = 0.020 * (A+B+C+D)						87,000	87,000
Contingency	31.3%	F = 0.313 * (A+B+C+D)						1,361,000	1,361,000
		Subtotal (G =B+C+D+E+F)						3,002,000	3,002,000
TOTAL CAPITAL COSTS (H = A+G)								5,803,000	5,803,000

Table A4-3 Cost Estimate - Basin A Plume Group
Alternative AC-3/AT-2: Mass Reduction, Air Stripping/GAC Adsorption

	Cost	Start	End	1992 ($)				------------- 1995 ($) Annual Cost	-------------		1995 ($)	1995 ($)
Cost Item	Type	Year	Year	Unit Cost	Units	Quantity	Units	Yr 1-5	Yr 6-10	Yr 11-30	Total Cost	PW Cost
DIRECT O&M COSTS (OPERATIONS)												
Control System												
Maintenance & Repair	A	1	10	57,035.00	/EA-YR	1	EA	65,000	65,000		651,000	528,000
Well & Pump Operations	A	1	10	4,153.00	/EA-YR	1	EA	5,000	5,000		47,000	38,000
Well System & Plume Evaluation Monitoring	A	1	30	96,303.00	/EA-YR	1	EA	110,000	110,000	110,000	3,297,000	1,747,000
Treatment System												
Treatment Facility, 1000 Square Feet	A	1	10	4,339.00	/EA-YR	1	EA	5,000	5,000		50,000	40,000
Collection System	A	1	10	33,366.00	/EA-YR	1	EA	38,000	38,000		381,000	309,000
Hardness/Iron Treatment Unit	A	1	10	9,657.00	/EA-YR	1	EA	11,000	11,000		110,000	89,000
Air Stripping Unit	A	1	10	19,617.00	/EA-YR	1	EA	22,000	22,000		224,000	182,000
Emissions Treatment Unit	A	1	10	32,495.00	/EA-YR	1	EA	37,000	37,000		371,000	301,000
Granular Activated Carbon Adsorption Unit	A	1	10	56,431.00	/EA-YR	1	EA	64,000	64,000		644,000	522,000
Process Monitoring	A	1	10	78,096.00	/EA-YR	1	EA	89,000	89,000		891,000	723,000
Continued Operation of Basin A Neck IRA	A	1	30	478,000.00	/EA-YR	1	EA	545,000	545,000	545,000	16,364,000	8,672,000
Subtotal (I)								991,000	991,000	655,000	23,030,000	13,150,000
COST CODE LMSL												
INDIRECT O&M COSTS (OPERATIONS)												
Indirects, Overhead & Profit 39.0% J = 0.390 * (I)								386,000	386,000	255,000	8,982,000	5,129,000
Resident Engineering 2.0% K = 0.020 * (I+J)								28,000	28,000	18,000	640,000	366,000
Contingency 31.3% L = 0.313 * (I+J+K)								439,000	439,000	290,000	10,204,000	5,826,000
Subtotal (O = J+K+L)								853,000	853,000	563,000	19,826,000	11,321,000
TOTAL O&M COSTS (T = I+O)								1,844,000	1,844,000	1,218,000	42,855,000	24,471,000
TOTAL CAPITAL COSTS AND TOTAL O&M COSTS (U = H+T)											48,700,000	30,300,000

Table A4-4 Cost Estimate - Basin A Plume Group
Alternative AC-3/AT-4: Mass Reduction. Oxidation/Air Stripping/GAC Adsorption

Cost Item			Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT CAPITAL COSTS											
Control System											
Extraction Wells & Pump Installation			LS	1	--	596,112.00	/EA	1	EA	680,000	680,000
Performance Monitoring Well Installation			LS	1	--	411,805.00	/EA	1	EA	470,000	470,000
Extraction Pipe & System Installation			LS	1	--	557,235.00	/EA	1	EA	636,000	636,000
Reinjection Pipe & System Installation			LS	1	--	201,664.00	/EA	1	EA	230,000	230,000
Recharge Trench Installation			LS	1	--	174,000.00	/EA	1	EA	199,000	199,000
Treatment System											
Balance of Capital Costs, Treatment			LS	1	--	417,678.00	/EA	1	EA	477,000	477,000
Treatment Facility, 1200 Square Feet			LS	1	--	78,958.00	/EA	1	EA	90,000	90,000
Collection System			LS	1	--	39,183.00	/EA	1	EA	45,000	45,000
Hardness/Iron Treatment Unit			LS	1	--	2,600.00	/EA	1	EA	3,000	3,000
Air Stripping Unit			LS	1	--	18,881.00	/EA	1	EA	22,000	22,000
Oxidation Unit			LS	1	--	85,061.00	/EA	1	EA	97,000	97,000
Emissions Treatment Unit			LS	1	--	46,900.00	/EA	1	EA	54,000	54,000
Granular Activated Carbon Adsorption Unit			LS	1	--	57,481.00	/EA	1	EA	66,000	66,000
		Subtotal (A)								3,067,000	3,067,000
COST CODE HMSS											
INDIRECT CAPITAL COSTS											
Mob/Demob	5.1%	B = 0.051 * (A)								157,000	157,000
Indirects, Overhead & Profit	41.5%	C = 0.415 * (A+B)								1,338,000	1,338,000
Engineering Design	4.5%	D = 0.045 * (A+B+C)								205,000	205,000
Resident Engineering	2.0%	E = 0.020 * (A+B+C+D)								95,000	95,000
Contingency	31.3%	F = 0.313 * (A+B+C+D)								1,490,000	1,490,000
		Subtotal (G =B+C+D+E+F)								3,286,000	3,286,000
TOTAL CAPITAL COSTS (H = A+G)										6,353,000	6,353,000

Table A4-4 Cost Estimate - Basin A Plume Group
Alternative AC-3/AT-4: Mass Reduction, Oxidation/Air Stripping/GAC Adsorption

Cost Item	Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Annual Cost Yr 1-5	Yr 6-10	Yr 11-30	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT O&M COSTS (OPERATIONS)												
Control System												
Maintenance & Repair	A	1	10	57,035.00	/EA-YR	1	EA	65,000	65,000		651,000	528,000
Well & Pump Operations	A	1	10	4,153.00	/EA-YR	1	EA	5,000	5,000		47,000	38,000
Well System & Plume Evaluation Monitoring	A	1	30	96,303.00	/EA-YR	1	EA	110,000	110,000	110,000	3,297,000	1,747,000
Treatment System												
Treatment Facility, 1200 Square Feet	A	1	10	4,339.00	/EA-YR	1	EA	5,000	5,000		50,000	40,000
Collection System	A	1	10	33,366.00	/EA-YR	1	EA	38,000	38,000		381,000	309,000
Hardness/Iron Treatment Unit	A	1	10	9,657.00	/EA-YR	1	EA	11,000	11,000		110,000	89,000
Air Stripping Unit	A	1	10	19,617.00	/EA-YR	1	EA	22,000	22,000		224,000	182,000
Oxidation Unit	A	1	10	25,228.00	/EA-YR	1	EA	29,000	29,000		288,000	233,000
Emissions Treatment Unit	A	1	10	32,495.00	/EA-YR	1	EA	37,000	37,000		371,000	301,000
Granular Activated Carbon Adsorption Unit	A	1	10	8,071.00	/EA-YR	1	EA	9,000	9,000		92,000	75,000
Process Monitoring	A	1	10	78,096.00	/EA-YR	1	EA	89,000	89,000		891,000	723,000
Continued Operation of Basin A Neck IRA	A	1	30	478,000.00	/EA-YR	1	EA	545,000	545,000	545,000	16,364,000	8,672,000
Subtotal (I)								965,000	965,000	655,000	22,766,000	12,936,000
COST CODE LLSL												
INDIRECT O&M COSTS (OPERATIONS)												
Indirects, Overhead & Profit 39.0% J = 0.390 * (I)								376,000	376,000	255,000	8,879,000	5,045,000
Resident Engineering 1.8% K = 0.018 * (I+J)								23,000	23,000	16,000	554,000	315,000
Contingency 30.0% L = 0.300 * (I+J+K)								409,000	409,000	278,000	9,660,000	5,489,000
Subtotal (O = J+K+L)								808,000	808,000	549,000	19,092,000	10,849,000
TOTAL O&M COSTS (T = I+O)								1,773,000	1,773,000	1,204,000	41,858,000	23,785,000
TOTAL CAPITAL COSTS AND TOTAL O&M COSTS (U = H+T)											48,200,000	30,100,000

Table A4-5 Cost Estimate - Basin A Plume Group
Alternative AC-7: Capping

Cost Item			Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT CAPITAL COSTS											
		Subtotal (A)								0	0
COST CODE HLSS											
INDIRECT CAPITAL COSTS											
Mob/Demob	4.5%	B = 0.045 * (A)								0	0
Indirects, Overhead & Profit	41.5%	C = 0.415 * (A+B)								0	0
Engineering Design	3.0%	D = 0.030 * (A+B+C)								0	0
Resident Engineering	1.8%	E = 0.018 * (A+B+C+D)								0	0
Contingency	30.0%	F = 0.300 * (A+B+C+D)								0	0
		Subtotal (G =B+C+D+E+F)								0	0
TOTAL CAPITAL COSTS (H = A+G)										0	0

Table A4-5 Cost Estimate - Basin A Plume Group
Alternative AC-7: Capping

Cost Item	Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Annual Cost Yr 1-5	1995 ($) Annual Cost Yr 6-10	1995 ($) Annual Cost Yr 11-30	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT O&M COSTS (OPERATIONS)												
Well System & Plume Evaluation Monitoring	A	1	30	44,917.00	/EA-YR	1	EA	51,000	51,000	51,000	1,538,000	815,000
Continued Operation of Basin A Neck IRA	A	1	30	478,000.00	/EA-YR	1	EA	545,000	545,000	545,000	16,364,000	8,672,000
Subtotal (I)								596,000	596,000	596,000	17,902,000	9,487,000
COST CODE LLSL												
INDIRECT O&M COSTS (OPERATIONS)												
Indirects, Overhead & Profit 39.0% J = 0.390 * (I)								232,000	232,000	232,000	6,982,000	3,700,000
Resident Engineering 1.8% K = 0.018 * (I+J)								14,000	14,000	14,000	435,000	231,000
Contingency 30.0% L = 0.300 * (I+J+K)								253,000	253,000	253,000	7,596,000	4,025,000
Subtotal (O = J+K+L)								499,000	499,000	499,000	15,013,000	7,956,000
TOTAL O&M COSTS (T = I+O)								1,095,000	1,095,000	1,095,000	32,915,000	17,443,000
TOTAL CAPITAL COSTS AND TOTAL O&M COSTS (U = H+T)											32,900,000	17,400,000

Table A5-1 Cost Estimate - South Plants Plume Group
Alternative SPC-1: No Action

Cost Item			Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT CAPITAL COSTS											
		Subtotal (A)								0	0
COST CODE LLSS											
INDIRECT CAPITAL COSTS											
Mob/Demob	3.3%	B = 0.033 * (A)								0	0
Indirects, Overhead & Profit	39.0%	C = 0.390 * (A+B)								0	0
Engineering Design	3.0%	D = 0.030 * (A+B+C)								0	0
Resident Engineering	1.3%	E = 0.013 * (A+B+C+D)								0	0
Contingency	26.3%	F = 0.263 * (A+B+C+D)								0	0
		Subtotal (G =B+C+D+E+F)								0	0
TOTAL CAPITAL COSTS (H = A+G)										0	0

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Table A5-1 Cost Estimate - South Plants Plume Group
Alternative SPC-1: No Action

Cost Item	Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Annual Cost Yr 1-5	1995 ($) Annual Cost Yr 6-10	1995 ($) Annual Cost Yr 11-30	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT O&M COSTS (OPERATIONS)												
Well System & Plume Evaluation Monitoring	A	1	30	53,901.00	/EA-YR	1	EA	62,000	62,000	62,000	1,845,000	978,000
Subtotal (I)								62,000	62,000	62,000	1,845,000	978,000
COST CODE LLSL												
INDIRECT O&M COSTS (OPERATIONS)												
Indirects, Overhead & Profit 39.0% J = 0.390 * (I)								24,000	24,000	24,000	720,000	381,000
Resident Engineering 1.8% K = 0.018 * (I+J)								2,000	2,000	2,000	45,000	24,000
Contingency 30.0% L = 0.300 * (I+J+K)								26,000	26,000	26,000	783,000	415,000
Subtotal (O = J+K+L)								52,000	52,000	52,000	1,548,000	820,000
TOTAL O&M COSTS (T = I+O)								114,000	114,000	114,000	3,393,000	1,798,000
TOTAL CAPITAL COSTS AND TOTAL O&M COSTS (U = H+T)											3,390,000	1,800,000

Table A5-2 Cost Estimate - South Plants Plume Group

Alternative SPC-3/SPT-2: Mass Reduction, Air Stripping/GAC Adsorption

Cost Item			Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT CAPITAL COSTS											
Control System											
Extraction Wells & Pump Installation			LS	1	--	303,056.00	/EA	1	EA	346,000	346,000
Extraction Wells & Pump Installation, LNAPL			LS	1	--	19,818.00	/EA	1	EA	23,000	23,000
Performance Monitoring Well Installation			LS	1	--	139,928.00	/EA	1	EA	160,000	160,000
Extraction Pipe & System Installation			LS	1	--	254,111.00	/EA	1	EA	290,000	290,000
Reinjection Pipe & System Installation			LS	1	--	136,749.00	/EA	1	EA	156,000	156,000
Recharge Trench Installation			LS	1	--	174,000.00	/EA	1	EA	199,000	199,000
Extraction Wells & Pump Installation, LNAPL			LS	1	--	19,818.00	/EA	1	EA	23,000	23,000
Treatment System											
Balance of Capital Costs, Treatment			LS	1	--	280,395.00	/EA	1	EA	320,000	320,000
Treatment Facility, 1000 Square Feet			LS	1	--	75,062.00	/EA	1	EA	86,000	86,000
Collection System			LS	1	--	38,683.00	/EA	1	EA	44,000	44,000
Hardness/Iron Treatment Unit			LS	1	--	2,600.00	/EA	1	EA	3,000	3,000
Air Stripping Unit			LS	1	--	18,867.00	/EA	1	EA	22,000	22,000
Emissions Treatment Unit			LS	1	--	46,900.00	/EA	1	EA	54,000	54,000
Granular Activated Carbon Adsorption Unit			LS	1	--	57,482.00	/EA	1	EA	66,000	66,000
		Subtotal (A)								1,789,000	1,789,000
COST CODE HMSS											
INDIRECT CAPITAL COSTS											
Mob/Demob	5.1%	B = 0.051 * (A)								92,000	92,000
Indirects, Overhead & Profit	41.5%	C = 0.415 * (A+B)								780,000	780,000
Engineering Design	4.5%	D = 0.045 * (A+B+C)								120,000	120,000
Resident Engineering	2.0%	E = 0.020 * (A+B+C+D)								56,000	56,000
Contingency	31.3%	F = 0.313 * (A+B+C+D)								869,000	869,000
		Subtotal (G =B+C+D+E+F)								1,916,000	1,916,000
TOTAL CAPITAL COSTS (H = A+G)										3,705,000	3,705,000

Table A5-2 Cost Estimate - South Plants Plume Group
Alternative SPC-3/SPT-2: Mass Reduction, Air Stripping/GAC Adsorption

Cost Item	Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Annual Cost Yr 1-5	Yr 6-10	Yr 11-30	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT O&M COSTS (OPERATIONS)												
Control System												
Maintenance & Repair	A	1	10	43,974.00	/EA-YR	1	EA	50,000	50,000		502,000	407,000
Maintenance & Repair, LNAPL	A	1	5	1,360.00	/EA-YR	1	EA	2,000			8,000	7,000
Well & Pump Operations	A	1	10	3,607.00	/EA-YR	1	EA	4,000	4,000		41,000	33,000
Well & Pump Operations, LNAPL	A	1	5	510.00	/EA-YR	1	EA	1,000			3,000	3,000
Well System & Plume Evaluation Monitoring	A	1	30	71,573.00	/EA-YR	1	EA	82,000	82,000	82,000	2,450,000	1,299,000
Treatment System												
Treatment Facility, 1000 Square Feet	A	1	10	4,339.00	/EA-YR	1	EA	5,000	5,000		50,000	40,000
Collection System	A	1	10	33,366.00	/EA-YR	1	EA	38,000	38,000		381,000	309,000
Hardness/Iron Treatment Unit	A	1	10	9,657.00	/EA-YR	1	EA	11,000	11,000		110,000	89,000
Air Stripping Unit	A	1	10	18,841.00	/EA-YR	1	EA	22,000	22,000		215,000	174,000
Emissions Treatment Unit	A	1	10	32,301.00	/EA-YR	1	EA	37,000	37,000		369,000	299,000
Granular Activated Carbon Adsorption Unit	A	1	10	29,388.00	/EA-YR	1	EA	34,000	34,000		335,000	272,000
Light Non-Aqueous Phase Liquid Disposal	A	1	5	2,876.00	/EA-YR	1	EA	3,000			16,000	15,000
Process Monitoring	A	1	10	73,866.00	/EA-YR	1	EA	84,000	84,000		843,000	683,000
Subtotal (I)								373,000	367,000	82,000	5,323,000	3,630,000
COST CODE LMSL												
INDIRECT O&M COSTS (OPERATIONS)												
Indirects, Overhead & Profit 39.0% J = 0.390 * (I)								145,000	143,000	32,000	2,076,000	1,416,000
Resident Engineering 2.0% K = 0.020 * (I+J)								10,000	10,000	2,000	148,000	101,000
Contingency 31.3% L = 0.313 * (I+J+K)								165,000	163,000	36,000	2,358,000	1,608,000
Subtotal (O = J+K+L)								320,000	316,000	70,000	4,582,000	3,125,000
TOTAL O&M COSTS (T = I+O)								693,000	683,000	152,000	9,905,000	6,755,000
TOTAL CAPITAL COSTS AND TOTAL O&M COSTS (U = H+T)											13,600,000	10,500,000

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Table A5-3 Cost Estimate - South Plants Plume Group
Alternative SPC-3/SPT-3: Mass Reduction, Oxidation/GAC Adsorption

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Cost Item	Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT CAPITAL COSTS									
Control System									
Extraction Wells & Pump Installation	LS	1	--	303,056.00	/EA	1	EA	346,000	346,000
Performance Monitoring Well Installation	LS	1	--	139,928.00	/EA	1	EA	160,000	160,000
Extraction Pipe & System Installation	LS	1	--	254,111.00	/EA	1	EA	290,000	290,000
Reinjection Pipe & System Installation	LS	1	--	136,749.00	/EA	1	EA	156,000	156,000
Recharge Trench Installation	LS	1	--	174,000.00	/EA	1	EA	199,000	199,000
Extraction Wells & Pump Installation, LNAPL	LS	1	--	19,818.00	/EA	1	EA	23,000	23,000
Treatment System									
Balance of Capital Costs, Treatment	LS	1	--	389,503.00	/EA	1	EA	444,000	444,000
Treatment Facility, 1000 Square Feet	LS	1	--	75,062.00	/EA	1	EA	86,000	86,000
Collection System	LS	1	--	39,183.00	/EA	1	EA	45,000	45,000
Oxidation Unit	LS	1	--	85,061.00	/EA	1	EA	97,000	97,000
Emissions Treatment Unit	LS	1	--	46,900.00	/EA	1	EA	54,000	54,000
Granular Activated Carbon Adsorption Unit	LS	1	--	58,722.00	/EA	1	EA	67,000	67,000
Light Non-Aqueous Phase Liquid Disposal	LS	1	--	3,370.00	/EA	1	EA	4,000	4,000
Subtotal (A)								1,969,000	1,969,000

COST CODE HMSS

INDIRECT CAPITAL COSTS			1995 ($) Total Cost	1995 ($) PW Cost
Mob/Demob	5.1%	B = 0.051 * (A)	101,000	101,000
Indirects, Overhead & Profit	41.5%	C = 0.415 * (A+B)	859,000	859,000
Engineering Design	4.5%	D = 0.045 * (A+B+C)	132,000	132,000
Resident Engineering	2.0%	E = 0.020 * (A+B+C+D)	61,000	61,000
Contingency	31.3%	F = 0.313 * (A+B+C+D)	956,000	956,000
		Subtotal (G =B+C+D+E+F)	2,109,000	2,109,000
TOTAL CAPITAL COSTS (H = A+G)			4,079,000	4,079,000

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Table A5-3 Cost Estimate - South Plants Plume Group
Alternative SPC-3/SPT-3: Mass Reduction, Oxidation/GAC Adsorption

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Cost Item	Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Annual Cost Yr 1-5	1995 ($) Annual Cost Yr 6-10	1995 ($) Annual Cost Yr 11-30	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT O&M COSTS (OPERATIONS)												
Control System												
Well System & Plume Evaluation Monitoring	A	1	30	71,573.00	/EA-YR	1	EA	82,000	82,000	82,000	2,450,000	1,299,000
Maintenance & Repair	A	1	10	43,974.00	/EA-YR	1	EA	50,000	50,000		502,000	407,000
Well & Pump Operations	A	1	10	3,607.00	/EA-YR	1	EA	4,000	4,000		41,000	33,000
Maintenance & Repair, LNAPL	A	1	5	1,360.00	/EA-YR	1	EA	2,000			8,000	7,000
Well & Pump Operations, LNAPL	A	1	5	510.00	/EA-YR	1	EA	1,000			3,000	3,000
Treatment System												
Treatment Facility, 1000 Square Feet	A	1	10	4,339.00	/EA-YR	1	EA	5,000	5,000		50,000	40,000
Collection System	A	1	10	33,366.00	/EA-YR	1	EA	38,000	38,000		381,000	309,000
Oxidation Unit	A	1	10	25,228.00	/EA-YR	1	EA	29,000	29,000		288,000	233,000
Emissions Treatment Unit	A	1	10	32,400.00	/EA-YR	1	EA	37,000	37,000		370,000	300,000
Granular Activated Carbon Adsorption Unit	A	1	10	12,622.00	/EA-YR	1	EA	14,000	14,000		144,000	117,000
Light Non-Aqueous Phase Liquid Disposal	A	1	5	2,876.00	/EA-YR	1	EA	3,000			16,000	15,000
Process Monitoring	A	1	10	73,866.00	/EA-YR	1	EA	84,000	84,000		843,000	683,000
Subtotal (I)								349,000	343,000	82,000	5,095,000	3,446,000
COST CODE LMSL												
INDIRECT O&M COSTS (OPERATIONS)												
Indirects, Overhead & Profit 39.0% J = 0.390 * (I)								136,000	134,000	32,000	1,987,000	1,344,000
Resident Engineering 2.0% K = 0.020 * (I+J)								10,000	10,000	2,000	142,000	96,000
Contingency 31.3% L = 0.313 * (I+J+K)								155,000	152,000	36,000	2,258,000	1,527,000
Subtotal (O = J+K+L)								301,000	296,000	70,000	4,386,000	2,966,000
TOTAL O&M COSTS (T = I+O)								650,000	639,000	152,000	9,482,000	6,412,000
TOTAL CAPITAL COSTS AND TOTAL O&M COSTS (U = H+T)											13,600,000	10,500,000

Table A5-4 Cost Estimate - South Plants Plume Group

Alternative SPC-3/SPT-2/SPT-4: Mass Reduction, Air Stripping/GAC Adsorption, Biological Reactor/GAC Adsorption

Cost Item	Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT CAPITAL COSTS									
Control System									
Extraction Wells & Pump Installation	LS	1	--	303,056.00	/EA	1	EA	346,000	346,000
Performance Monitoring Well Installation	LS	1	--	139,928.00	/EA	1	EA	160,000	160,000
Extraction Pipe & System Installation	LS	1	--	254,111.00	/EA	1	EA	290,000	290,000
Reinjection Pipe & System Installation	LS	1	--	136,749.00	/EA	1	EA	156,000	156,000
Recharge Trench Installation	LS	1	--	174,000.00	/EA	1	EA	199,000	199,000
Extraction Wells & Pump Installation, LNAPL	LS	1	--	19,818.00	/EA	1	EA	23,000	23,000
Treatment System									
Balance of Capital Costs, Treatment	LS	1	--	463,206.00	/EA	1	EA	529,000	529,000
Treatment Facility, 1000 Square Feet	LS	1	--	75,062.00	/EA	1	EA	86,000	86,000
Collection System	LS	1	--	29,728.00	/EA	1	EA	34,000	34,000
Hardness/Iron Treatment Unit	LS	1	--	2,600.00	/EA	1	EA	3,000	3,000
Air Stripping Unit	LS	1	--	18,857.00	/EA	1	EA	22,000	22,000
Emissions Treatment Unit	LS	1	--	46,900.00	/EA	1	EA	54,000	54,000
Granular Activated Carbon Adsorption Unit	LS	1	--	57,482.00	/EA	1	EA	66,000	66,000
Light Non-Aqueous Phase Liquid Disposal	LS	1	--	3,370.00	/EA	1	EA	4,000	4,000
Direct Biological Treatment Unit	LS	1	--	125,977.00	/EA	1	EA	144,000	144,000
Subtotal (A)								2,112,000	2,112,000

COST CODE HMSS

Cost Item			1995 ($) Total Cost	1995 ($) PW Cost
INDIRECT CAPITAL COSTS				
Mob/Demob	5.1%	B = 0.051 * (A)	108,000	108,000
Indirects, Overhead & Profit	41.5%	C = 0.415 * (A+B)	921,000	921,000
Engineering Design	4.5%	D = 0.045 * (A+B+C)	141,000	141,000
Resident Engineering	2.0%	E = 0.020 * (A+B+C+D)	66,000	66,000
Contingency	31.3%	F = 0.313 * (A+B+C+D)	1,026,000	1,026,000
		Subtotal (G =B+C+D+E+F)	2,263,000	2,263,000
TOTAL CAPITAL COSTS (H = A+G)			4,375,000	4,375,000

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Table A5-4 Cost Estimate - South Plants Plume Group
Alternative SPC-3/SPT-2/SPT-4: Mass Reduction, Air Stripping/GAC Adsorption, Biological Reactor/GAC Adsorption

Cost Item	Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Annual Cost Yr 1-5	Yr 6-10	Yr 11-30	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT O&M COSTS (OPERATIONS)												
Control System												
Well System & Plume Evaluation Monitoring	A	1	30	71,573.00	/EA-YR	1	EA	82,000	82,000	82,000	2,450,000	1,299,000
Maintenance & Repair	A	1	10	43,974.00	/EA-YR	1	EA	50,000	50,000		502,000	407,000
Well & Pump Operations	A	1	10	3,607.00	/EA-YR	1	EA	4,000	4,000		41,000	33,000
Maintenance & Repair, LNAPL	A	1	5	1,360.00	/EA-YR	1	EA	2,000			8,000	7,000
Well & Pump Operations, LNAPL	A	1	5	510.00	/EA-YR	1	EA	1,000			3,000	3,000
Treatment System												
Treatment Facility, 1000 Square Feet	A	1	10	4,339.00	/EA-YR	1	EA	5,000	5,000		50,000	40,000
Collection System	A	1	10	30,571.00	/EA-YR	1	EA	35,000	35,000		349,000	283,000
Hardness/Iron Treatment Unit	A	1	10	9,657.00	/EA-YR	1	EA	11,000	11,000		110,000	89,000
Air Stripping Unit	A	1	10	18,064.00	/EA-YR	1	EA	21,000	21,000		206,000	167,000
Emissions Treatment Unit	A	1	10	32,270.00	/EA-YR	1	EA	37,000	37,000		368,000	299,000
Granular Activated Carbon Adsorption Unit	A	1	10	27,484.00	/EA-YR	1	EA	31,000	31,000		314,000	254,000
Light Non-Aqueous Phase Liquid Disposal	A	1	5	2,876.00	/EA-YR	1	EA	3,000			16,000	15,000
Process Monitoring	A	1	10	73,866.00	/EA-YR	1	EA	84,000	84,000		843,000	683,000
Direct Biological Treatment Unit	A	1	10	33,969.00	/EA-YR	1	EA	39,000	39,000		388,000	314,000
Process Monitoring, Direct Bio	A	1	10	29,216.00	/EA-YR	1	EA	33,000	33,000		333,000	270,000
Subtotal (I)								438,000	432,000	82,000	5,981,000	4,164,000
COST CODE LMSL												
INDIRECT O&M COSTS (OPERATIONS)												
Indirects, Overhead & Profit 39.0% J = 0.390 * (I)								171,000	168,000	32,000	2,333,000	1,624,000
Resident Engineering 2.0% K = 0.020 * (I+J)								12,000	12,000	2,000	166,000	116,000
Contingency 31.3% L = 0.313 * (I+J+K)								194,000	191,000	36,000	2,650,000	1,845,000
Subtotal (O = J+K+L)								377,000	371,000	70,000	5,149,000	3,584,000
TOTAL O&M COSTS (T = I+O)								815,000	803,000	152,000	11,130,000	7,748,000
TOTAL CAPITAL COSTS AND TOTAL O&M COSTS (U = H+T)											15,500,000	12,100,000

Table A5-5 **Cost Estimate - South Plants Plume Group**
Alternative SPC-3/SPT-3/SPT-4: Mass Reduction, Oxidation/GAC Adsorption, Biological Reactor/GAC Adsorption

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Cost Item			Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT CAPITAL COSTS											
Control System											
Extraction Wells & Pump Installation			LS	1	--	303,056.00	/EA	1	EA	346,000	346,000
Performance Monitoring Well Installation			LS	1	--	139,928.00	/EA	1	EA	160,000	160,000
Extraction Pipe & System Installation			LS	1	--	254,111.00	/EA	1	EA	290,000	290,000
Reinjection Pipe & System Installation			LS	1	--	136,749.00	/EA	1	EA	156,000	156,000
Recharge Trench Installation			LS	1	--	174,000.00	/EA	1	EA	199,000	199,000
Extraction Wells & Pump Installation, LNAPL			LS	1	--	19,818.00	/EA	1	EA	23,000	23,000
Treatment System											
Balance of Capital Costs, Treatment			LS	1	--	794,008.00	/EA	1	EA	906,000	906,000
Treatment Facility, 1000 Square Feet			LS	1	--	75,062.00	/EA	1	EA	86,000	86,000
Collection System			LS	1	--	29,728.00	/EA	1	EA	34,000	34,000
Oxidation Unit			LS	1	--	266,442.00	/EA	1	EA	304,000	304,000
Granular Activated Carbon Adsorption Unit			LS	1	--	57,482.00	/EA	1	EA	66,000	66,000
Light Non-Aqueous Phase Liquid Disposal			LS	1	--	3,370.00	/EA	1	EA	4,000	4,000
Direct Biological Treatment Unit			LS	1	--	125,977.00	/EA	1	EA	144,000	144,000
		Subtotal (A)								2,716,000	2,716,000
COST CODE HMSS											
INDIRECT CAPITAL COSTS											
Mob/Demob	5.1%	B = 0.051 * (A)								139,000	139,000
Indirects, Overhead & Profit	41.5%	C = 0.415 * (A+B)								1,185,000	1,185,000
Engineering Design	4.5%	D = 0.045 * (A+B+C)								182,000	182,000
Resident Engineering	2.0%	E = 0.020 * (A+B+C+D)								84,000	84,000
Contingency	31.3%	F = 0.313 * (A+B+C+D)								1,319,000	1,319,000
		Subtotal (G =B+C+D+E+F)								2,909,000	2,909,000
TOTAL CAPITAL COSTS (H = A+G)										5,625,000	5,625,000

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Table A5-5 Cost Estimate - South Plants Plume Group
Alternative SPC-3/SPT-3/SPT-4: Mass Reduction, Oxidation/GAC Adsorption, Biological Reactor/GAC Adsorption

Cost Item	Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Annual Cost Yr 1-5	Yr 6-10	Yr 11-30	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT O&M COSTS (OPERATIONS)												
Control System												
Well System & Plume Evaluation Monitoring	A	1	30	71,573.00	/EA-YR	1	EA	82,000	82,000	82,000	2,450,000	1,299,000
Maintenance & Repair	A	1	10	43,974.00	/EA-YR	1	EA	50,000	50,000		502,000	407,000
Well & Pump Operations	A	1	10	3,607.00	/EA-YR	1	EA	4,000	4,000		41,000	33,000
Maintenance & Repair, LNAPL	A	1	5	1,360.00	/EA-YR	1	EA	2,000			8,000	7,000
Well & Pump Operations, LNAPL	A	1	5	510.00	/EA-YR	1	EA	1,000			3,000	3,000
Treatment System												
Treatment Facility, 1000 Square Feet	A	1	10	4,339.00	/EA-YR	1	EA	5,000	5,000		50,000	40,000
Collection System	A	1	10	33,366.00	/EA-YR	1	EA	38,000	38,000		381,000	309,000
Oxidation Unit	A	1	10	81,717.00	/EA-YR	1	EA	93,000	93,000		933,000	756,000
Granular Activated Carbon Adsorption Unit	A	1	10	9,049.00	/EA-YR	1	EA	10,000	10,000		103,000	84,000
Light Non-Aqueous Phase Liquid Disposal	A	1	5	2,876.00	/EA-YR	1	EA	3,000			16,000	15,000
Process Monitoring	A	1	10	73,866.00	/EA-YR	1	EA	84,000	84,000		843,000	683,000
Direct Biological Treatment Unit	A	1	10	33,969.00	/EA-YR	1	EA	39,000	39,000		388,000	314,000
Process Monitoring, Direct Bio	A	1	10	29,216.00	/EA-YR	1	EA	33,000	33,000		333,000	270,000
Subtotal (I)								444,000	438,000	82,000	6,050,000	4,220,000
COST CODE LMSL												
INDIRECT O&M COSTS (OPERATIONS)												
Indirects, Overhead & Profit 39.0% J = 0.390 * (I)								173,000	171,000	32,000	2,360,000	1,646,000
Resident Engineering 2.0% K = 0.020 * (I+J)								12,000	12,000	2,000	168,000	117,000
Contingency 31.3% L = 0.313 * (I+J+K)								197,000	194,000	36,000	2,681,000	1,870,000
Subtotal (O = J+K+L)								382,000	377,000	70,000	5,209,000	3,633,000
TOTAL O&M COSTS (T = I+O)								826,000	815,000	152,000	11,259,000	7,853,000
TOTAL CAPITAL COSTS AND TOTAL O&M COSTS (U = II+T)											16,900,000	13,500,000

Table A5-6 **Cost Estimate - South Plants Plume Group**
Alternative SPC-5/SPT-2/SPT-5: Mass Reduction, Air Stripping/GAC Adsorption, In-Situ Biodegradation

Cost Item			Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT CAPITAL COSTS											
Control System											
Extraction Wells & Pump Installation			LS	1	--	507,601.00	/EA	1	EA	579,000	579,000
Injection Well Installation			LS	1	--	264,929.00	/EA	1	EA	302,000	302,000
Performance Monitoring Well Installation			LS	1	--	376,730.00	/EA	1	EA	430,000	430,000
Extraction Pipe & System Installation			LS	1	--	281,517.00	/EA	1	EA	321,000	321,000
Reinjection Pipe & System Installation			LS	1	--	121,863.00	/EA	1	EA	139,000	139,000
Recharge Trench Installation			LS	1	--	174,000.00	/EA	1	EA	199,000	199,000
Extraction Wells & Pump Installation, LNAPL			LS	1	--	19,818.00	/EA	1	EA	23,000	23,000
Treatment System											
Balance of Capital Costs, Phase I			LS	1	--	5,325.00	/EA	1	EA	6,000	6,000
Collection System			LS	1	--	22.00	/EA	1	EA	25	25
Light Non-Aqueous Phase Liquid Disposal			LS	1	--	3,370.00	/EA	1	EA	4,000	4,000
In Situ Biodegradation System											
Balance of Capital Costs, In Situ Treatment			LS	1	--	17,183.00	/EA	1	EA	20,000	20,000
Treatment Facility, In Situ Bio			LS	1	--	22,291.00	/EA	1	EA	25,000	25,000
Collection System, In Situ Bio			LS	1	--	5,089.00	/EA	1	EA	6,000	6,000
In Situ Biodegradation Unit			LS	1	--	5,200.00	/EA	1	EA	6,000	6,000
		Subtotal (A)								2,060,000	2,060,000
COST CODE HMSS											
INDIRECT CAPITAL COSTS											
Mob/Demob	5.1%	B = 0.051 * (A)								106,000	106,000
Indirects, Overhead & Profit	41.5%	C = 0.415 * (A+B)								899,000	899,000
Engineering Design	4.5%	D = 0.045 * (A+B+C)								138,000	138,000
Resident Engineering	2.0%	E = 0.020 * (A+B+C+D)								64,000	64,000
Contingency	31.3%	F = 0.313 * (A+B+C+D)								1,001,000	1,001,000
		Subtotal (G =B+C+D+E+F)								2,207,000	2,207,000
TOTAL CAPITAL COSTS (H = A+G)										4,266,000	4,266,000

Table A5-6 Cost Estimate - South Plants Plume Group
Alternative SPC-5/SPT-2/SPT-5: Mass Reduction, Air Stripping/GAC Adsorption, In-Situ Biodegradation

	Cost	Start	End	1992 ($)				1995 ($) Annual Cost			1995 ($)	1995 ($)
Cost Item	Type	Year	Year	Unit Cost	Units	Quantity	Units	Yr 1-5	Yr 6-10	Yr 11-30	Total Cost	PW Cost
DIRECT O&M COSTS (OPERATIONS)												
Control System												
Maintenance & Repair	A	1	10	85,321.00	/EA-YR	1	EA	97,000	97,000		974,000	789,000
Well & Pump Operations	A	1	10	5,138.00	/EA-YR	1	EA	6,000	6,000		59,000	48,000
Well System & Plume Evaluation Monitoring	A	1	30	115,054.00	/EA-YR	1	EA	131,000	131,000	131,000	3,939,000	2,087,000
Maintenance & Repair, LNAPL	A	1	5	1,360.00	/EA-YR	1	EA	2,000			8,000	7,000
Well & Pump Operations, LNAPL	A	1	5	510.00	/EA-YR	1	EA	1,000			3,000	3,000
Treatment System												
Collection System	A	1	10	1,118.00	/EA-YR	1	EA	1,000	1,000		13,000	10,000
Hardness/Iron Treatment Unit	A	1	10	1.00	/EA-YR	1	EA	1	1		11	9
Granular Activated Carbon Adsorption Unit	A	1	10	6,521.00	/EA-YR	1	EA	7,000	7,000		74,000	60,000
Light Non-Aqueous Phase Liquid Disposal	A	1	5	2,876.00	/EA-YR	1	EA	3,000			16,000	15,000
In Situ Biodegradation System												
Treatment Facility, In Situ Bio	A	1	10	3,139.00	/EA-YR	1	EA	4,000	4,000		36,000	29,000
Collection System, In Situ Bio	A	1	10	5,268.00	/EA-YR	1	EA	6,000	6,000		60,000	49,000
In Situ Biodegradation Unit	A	1	10	11,892.00	/EA-YR	1	EA	14,000	14,000		136,000	110,000
Process Monitoring, In Situ Bio	A	1	10	15,116.00	/EA-YR	1	EA	17,000	17,000		172,000	140,000
Subtotal (I)								289,001	283,001	131,000	5,490,000	3,347,000
COST CODE LMSL												
INDIRECT O&M COSTS (OPERATIONS)												
Indirects, Overhead & Profit 39.0% J = 0.390 * (I)								113,000	110,000	51,000	2,141,000	1,305,000
Resident Engineering 2.0% K = 0.020 * (I+J)								8,000	8,000	4,000	153,000	93,000
Contingency 31.3% L = 0.313 * (I+J+K)								128,000	125,000	58,000	2,432,000	1,483,000
Subtotal (O = J+K+L)								249,000	243,000	113,000	4,726,000	2,882,000
TOTAL O&M COSTS (T = I+O)								538,000	526,000	244,000	10,215,000	6,229,000
TOTAL CAPITAL COSTS AND TOTAL O&M COSTS (U = II+T)											14,500,000	10,500,000

Table A5-7 Cost Estimate - South Plants Plume Group

Alternative SPC-6/SPT-2/SPT-5: Mass Reduction/Dewatering, Air Stripping/GAC Adsorption, In Situ Biodegradation

Cost Item	Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT CAPITAL COSTS									
Phase I, Control System									
Extraction Wells & Pump Installation	LS	1	--	507,601.00	/EA	1	EA	579,000	579,000
Injection Well Installation	LS	1	--	264,929.00	/EA	1	EA	302,000	302,000
Performance Monitoring Well Installation	LS	1	--	376,730.00	/EA	1	EA	430,000	430,000
Extraction Pipe & System Installation	LS	1	--	281,517.00	/EA	1	EA	321,000	321,000
Reinjection Pipe & System Installation	LS	1	--	121,863.00	/EA	1	EA	139,000	139,000
Recharge Trench Installation	LS	1	--	174,000.00	/EA	1	EA	199,000	199,000
Extraction Wells & Pump Installation, LNAPL	LS	1	--	19,818.00	/EA	1	EA	23,000	23,000
Phase II, Control System									
Extraction Wells & Pump Installation	LS	10	--	794,223.00	/EA	1	EA	906,000	584,000
Performance Monitoring Well Installation	LS	10	--	215,874.00	/EA	1	EA	246,000	159,000
Extraction Pipe & System Installation	LS	10	--	525,525.00	/EA	1	EA	600,000	387,000
Phase I, Treatment System									
Balance of Capital Costs, Phase I	LS	1	--	5,325.00	/EA	1	EA	6,000	6,000
Collection System	LS	1	--	22.00	/EA	1	EA	25	25
Light Non-Aqueous Phase Liquid Disposal	LS	1	--	3,370.00	/EA	1	EA	4,000	4,000
In Situ Biodegradation System									
Balance of Capital Costs, In Situ Treatment	LS	1	--	17,183.00	/EA	1	EA	20,000	20,000
Treatment Facility, In Situ Bio	LS	1	--	22,291.00	/EA	1	EA	25,000	25,000
Collection System, In Situ Bio	LS	1	--	5,089.00	/EA	1	EA	6,000	6,000
In Situ Biodegradation Unit	LS	1	--	5,200.00	/EA	1	EA	6,000	6,000
Phase II, Treatment System									
Balance of Capital Costs, Phase II	LS	10	--	320,800.00	/EA	1	EA	366,000	236,000
Treatment Facility, 1500 Square Feet	LS	10	--	84,324.00	/EA	1	EA	96,000	62,000
Collection System, Phase II	LS	10	--	55,384.00	/EA	1	EA	63,000	41,000
Hardness/Iron Treatment Unit, Phase II	LS	10	--	2,600.00	/EA	1	EA	3,000	2,000
Air Stripping Unit	LS	10	--	20,942.00	/EA	1	EA	24,000	15,000
Emissions Treatment Unit	LS	10	--	54,430.00	/EA	1	EA	62,000	40,000
Granular Activated Carbon Adsorption Unit	LS	10	--	58,740.00	/EA	1	EA	67,000	43,000
COST CODE HMSS Subtotal (A)								4,494,000	3,629,000
INDIRECT CAPITAL COSTS									
Mob/Demob 5.1% B = 0.051 * (A)								230,000	186,000
Indirects, Overhead & Profit 41.5% C = 0.415 * (A+B)								1,960,000	1,583,000
Engineering Design 1.5% D = 0.015 * (A+B+C)								100,000	81,000
Resident Engineering 2.0% E = 0.020 * (A+B+C+D)								136,000	110,000
Contingency 31.3% F = 0.313 * (A+B+C+D)								2,120,000	1,712,000
Subtotal (G =B+C+D+E+F)								4,547,000	3,672,000
TOTAL CAPITAL COSTS (H = A+G)								9,041,000	7,300,000

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Table A5-7 Cost Estimate - South Plants Plume Group

Alternative SPC-6/SPT-2/SPT-5: Mass Reduction/Dewatering, Air Stripping/GAC Adsorption, In Situ Biodegradation

Cost Item	Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Annual Cost Yr 1-5	1995 ($) Annual Cost Yr 6-10	1995 ($) Annual Cost Yr 11-30	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT O&M COSTS (OPERATIONS)												
Phase I, Control System												
Maintenance & Repair	A	1	10	85,321.00	/EA-YR	1	EA	97,000	97,000		974,000	789,000
Well & Pump Operations	A	1	10	5,138.00	/EA-YR	1	EA	6,000	6,000		59,000	48,000
Maintenance & Repair, LNAPL	A	1	5	1,360.00	/EA-YR	1	EA	2,000			8,000	7,000
Well & Pump Operations, LNAPL	A	1	5	510.00	/EA-YR	1	EA	1,000			3,000	3,000
Phase II, Control System												
Maintenance & Repair	A	11	30	88,596.00	/EA-YR	1	EA			101,000	2,022,000	812,000
Well & Pump Operations	A	11	30	6,931.00	/EA-YR	1	EA			8,000	158,000	64,000
Well System & Plume Evaluation Monitoring	A	1	30	121,258.00	/EA-YR	1	EA	138,000	138,000	138,000	4,151,000	2,200,000
Phase I, Treatment System												
Collection System	A	1	10	1,118.00	/EA-YR	1	EA	1,000	1,000		13,000	10,000
Hardness/Iron Treatment Unit	A	1	10	1.00	/EA-YR	1	EA	1	1		11	9
Granular Activated Carbon Adsorption Unit	A	1	10	6,521.00	/EA-YR	1	EA	7,000	7,000		74,000	60,000
Light Non-Aqueous Phase Liquid Disposal	A	1	5	2,876.00	/EA-YR	1	EA	3,000			16,000	15,000
In Situ Biodegradation System												
Treatment Facility, In Situ Bio	A	1	10	3,139.00	/EA-YR	1	EA	4,000	4,000		36,000	29,000
Collection System, In Situ Bio	A	1	10	5,268.00	/EA-YR	1	EA	6,000	6,000		60,000	49,000
In Situ Biodegradation Unit	A	1	10	11,892.00	/EA-YR	1	EA	14,000	14,000		136,000	110,000
Process Monitoring, In Situ Bio	A	1	10	15,116.00	/EA-YR	1	EA	17,000	17,000		172,000	140,000
Phase II, Treatment System												
Treatment Facility, 1500 Square Feet	A	11	30	4,339.00	/EA-YR	1	EA			5,000	99,000	40,000
Collection System, Phase II	A	11	30	44,545.00	/EA-YR	1	EA			51,000	1,017,000	408,000
Hardness/Iron Treatment Unit, Phase II	A	11	30	9,663.00	/EA-YR	1	EA			11,000	221,000	89,000
Air Stripping Unit	A	11	30	26,004.00	/EA-YR	1	EA			30,000	593,000	238,000
Emissions Treatment Unit	A	11	30	33,498.00	/EA-YR	1	EA			38,000	765,000	307,000
Granular Activated Carbon Adsorption Unit	A	11	30	22,313.00	/EA-YR	1	EA			25,000	509,000	205,000
Process Monitoring	A	11	30	49,896.00	/EA-YR	1	EA			57,000	1,139,000	457,000
Subtotal (I)								296,000	290,000	464,000	12,225,000	6,080,000
COST CODE LMSL												
INDIRECT O&M COSTS (OPERATIONS)												
Indirects, Overhead & Profit 39.0% J = 0.390 * (I)								115,000	113,000	181,000	4,768,000	2,371,000
Resident Engineering 2.0% K = 0.020 * (I+J)								8,000	8,000	13,000	340,000	169,000
Contingency 31.3% L = 0.313 * (I+J+K)								131,000	128,000	206,000	5,416,000	2,694,000
Subtotal (O = J+K+L)								254,000	249,000	400,000	10,524,000	5,234,000
TOTAL O&M COSTS (T = I+O)								550,000	539,000	864,000	22,748,000	11,314,000
TOTAL CAPITAL COSTS AND TOTAL O&M COSTS (U = II+T)											31,800,000	18,600,000

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Table A5-8 Cost Estimate - South Plants Plume Group
Alternative SPC-6/SPT-3/SPT-5: Mass Reduction/Dewatering, Oxidation/GAC Adsorption, In Situ Biodegradation

Cost Item	Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT CAPITAL COSTS									
Phase I, Control System									
Extraction Wells & Pump Installation	LS	1	--	507,601.00	/EA	1	EA	579,000	579,000
Injection Well Installation	LS	1	--	264,929.00	/EA	1	EA	302,000	302,000
Performance Monitoring Well Installation	LS	1	--	376,730.00	/EA	1	EA	430,000	430,000
Extraction Pipe & System Installation	LS	1	--	281,517.00	/EA	1	EA	321,000	321,000
Reinjection Pipe & System Installation	LS	1	--	121,863.00	/EA	1	EA	139,000	139,000
Recharge Trench Installation	LS	1	--	174,000.00	/EA	1	EA	199,000	199,000
Extraction Wells & Pump Installation, LNAPL	LS	1	--	19,818.00	/EA	1	EA	23,000	23,000
Phase II, Control System									
Extraction Wells & Pump Installation	LS	10	--	794,223.00	/EA	1	EA	906,000	584,000
Performance Monitoring Well Installation	LS	10	--	215,874.00	/EA	1	EA	246,000	159,000
Extraction Pipe & System Installation	LS	10	--	525,525.00	/EA	1	EA	600,000	387,000
Phase I, Treatment System									
Balance of Capital Costs, Phase I	LS	1	--	5,325.00	/EA	1	EA	6,000	6,000
Collection System	LS	1	--	22.00	/EA	1	EA	25	25
Light Non-Aqueous Phase Liquid Disposal	LS	1	--	3,370.00	/EA	1	EA	4,000	4,000
In Situ Biodegradation System									
Balance of Capital Costs, In Situ Treatment	LS	1	--	17,183.00	/EA	1	EA	20,000	20,000
Treatment Facility, In Situ Bio	LS	1	--	22,291.00	/EA	1	EA	25,000	25,000
Collection System, In Situ Bio	LS	1	--	5,089.00	/EA	1	EA	6,000	6,000
In Situ Biodegradation Unit	LS	1	--	5,200.00	/EA	1	EA	6,000	6,000
Phase II, Treatment System									
Balance of Capital Costs, Phase II	LS	10	--	378,264.00	/EA	1	EA	432,000	278,000
Treatment Facility, 1500 Square Feet	LS	10	--	84,324.00	/EA	1	EA	96,000	62,000
Collection System, Phase II	LS	10	--	55,884.00	/EA	1	EA	64,000	41,000
Oxidation Unit	LS	10	--	110,256.00	/EA	1	EA	126,000	81,000
Emissions Treatment Unit	LS	10	--	2,865.00	/EA	1	EA	3,000	2,000
Granular Activated Carbon Adsorption Unit	LS	10	--	57,500.00	/EA	1	EA	66,000	42,000
Subtotal (A)								4,599,000	3,696,000
COST CODE HMSS									
INDIRECT CAPITAL COSTS									
Mob/Demob 5.1% B = 0.051 * (A)								236,000	189,000
Indirects, Overhead & Profit 41.5% C = 0.415 * (A+B)								2,006,000	1,613,000
Engineering Design 4.5% D = 0.045 * (A+B+C)								308,000	247,000
Resident Engineering 2.0% E = 0.020 * (A+B+C+D)								143,000	115,000
Contingency 31.3% F = 0.313 * (A+B+C+D)								2,234,000	1,796,000
Subtotal (G =B+C+D+E+F)								4,926,000	3,960,000
TOTAL CAPITAL COSTS (H = A+G)								9,525,000	7,656,000

Table A5-8 Cost Estimate - South Plants Plume Group
Alternative SPC-6/SPT-3/SPT-5: Mass Reduction/Dewatering, Oxidation/GAC Adsorption, In Situ Biodegradation

Cost Item	Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Annual Cost Yr 1-5	1995 ($) Annual Cost Yr 6-10	1995 ($) Annual Cost Yr 11-30	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT O&M COSTS (OPERATIONS)												
Phase I, Control System												
Maintenance & Repair	A	1	10	85,321.00	/EA-YR	1	EA	97,000	97,000		974,000	789,000
Well & Pump Operations	A	1	10	5,138.00	/EA-YR	1	EA	6,000	6,000		59,000	48,000
Maintenance & Repair, LNAPL	A	1	5	1,360.00	/EA-YR	1	EA	2,000			8,000	7,000
Well & Pump Operations, LNAPL	A	1	5	510.00	/EA-YR	1	EA	1,000			3,000	3,000
Phase II, Control System												
Maintenance & Repair	A	11	30	88,596.00	/EA-YR	1	EA			101,000	2,022,000	812,000
Well & Pump Operations	A	11	30	6,931.00	/EA-YR	1	EA			8,000	158,000	64,000
Well System & Plume Evaluation Monitoring	A	1	30	121,258.00	/EA-YR	1	EA	138,000	138,000	138,000	4,151,000	2,200,000
Phase I, Treatment System												
Collection System	A	1	10	1,118.00	/EA-YR	1	EA	1,000	1,000		13,000	10,000
Hardness/Iron Treatment Unit	A	1	10	1.00	/EA-YR	1	EA	1	1		11	9
Granular Activated Carbon Adsorption Unit	A	1	10	6,521.00	/EA-YR	1	EA	7,000	7,000		74,000	60,000
Light Non-Aqueous Phase Liquid Disposal	A	1	5	2,876.00	/EA-YR	1	EA	3,000			16,000	15,000
In Situ Biodegradation System												
Treatment Facility, In Situ Bio	A	1	10	3,139.00	/EA-YR	1	EA	4,000	4,000		36,000	29,000
Collection System, In Situ Bio	A	1	10	5,268.00	/EA-YR	1	EA	6,000	6,000		60,000	49,000
In Situ Biodegradation Unit	A	1	10	11,892.00	/EA-YR	1	EA	14,000	14,000		136,000	110,000
Process Monitoring, In Situ Bio	A	1	10	15,116.00	/EA-YR	1	EA	17,000	17,000		172,000	140,000
Phase II, Treatment System												
Treatment Facility, 1500 Square Feet	A	11	30	4,339.00	/EA-YR	1	EA			5,000	99,000	40,000
Collection System, Phase II	A	11	30	44,545.00	/EA-YR	1	EA			51,000	1,017,000	408,000
Oxidation Unit	A	11	30	49,973.00	/EA-YR	1	EA			57,000	1,141,000	458,000
Emissions Treatment Unit	A	11	30	33,856.00	/EA-YR	1	EA			39,000	773,000	310,000
Granular Activated Carbon Adsorption Unit	A	11	30	12,335.00	/EA-YR	1	EA			14,000	282,000	113,000
Process Monitoring	A	11	30	49,896.00	/EA-YR	1	EA			57,000	1,139,000	457,000
Subtotal (I)								296,001	290,001	470,000	12,331,000	6,123,000
COST CODE LMSL												
INDIRECT O&M COSTS (OPERATIONS)												
Indirects, Overhead & Profit 39.0% J = 0.390 * (I)								115,000	113,000	183,000	4,809,000	2,388,000
Resident Engineering 2.0% K = 0.020 * (I+J)								8,000	8,000	13,000	343,000	170,000
Contingency 31.3% L = 0.313 * (I+J+K)								131,000	128,000	208,000	5,464,000	2,713,000
Subtotal (O = J+K+L)								254,000	249,000	404,000	10,616,000	5,271,000
TOTAL O&M COSTS (T = I+O)								550,000	539,000	874,000	22,947,000	11,393,000
TOTAL CAPITAL COSTS AND TOTAL O&M COSTS (U = H+T)											32,500,000	19,000,000

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Table A5-9 Cost Estimate - South Plants Plume Group

Alternative SPC-7/SPT-2/SPT-5: Mass Reduction/Dewatering, Air Stripping/GAC Adsorption, In Situ Biodegradation

Cost Item	Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT CAPITAL COSTS									
Phase I, Control System									
Extraction Wells & Pump Installation	LS	1	--	507,601.00	/EA	1	EA	579,000	579,000
Injection Well Installation	LS	1	--	264,929.00	/EA	1	EA	302,000	302,000
Performance Monitoring Well Installation	LS	1	--	376,730.00	/EA	1	EA	430,000	430,000
Extraction Pipe & System Installation	LS	1	--	281,517.00	/EA	1	EA	321,000	321,000
Reinjection Pipe & System Installation	LS	1	--	121,863.00	/EA	1	EA	139,000	139,000
Recharge Trench Installation	LS	1	--	174,000.00	/EA	1	EA	199,000	199,000
Extraction Wells & Pump Installation, LNAPL	LS	1	--	19,818.00	/EA	1	EA	23,000	23,000
Phase II, Control System									
Extraction Wells & Pump Installation	LS	10	--	794,223.00	/EA	1	EA	906,000	584,000
Performance Monitoring Well Installation	LS	10	--	215,874.00	/EA	1	EA	246,000	159,000
Extraction Pipe & System Installation	LS	10	--	525,525.00	/EA	1	EA	600,000	387,000
Phase I, Treatment System									
Balance of Capital Costs, Phase I	LS	1	--	5,325.00	/EA	1	EA	6,000	6,000
Collection System	LS	1	--	22.00	/EA	1	EA	25	25
Light Non-Aqueous Phase Liquid Disposal	LS	1	--	3,370.00	/EA	1	EA	4,000	4,000
In Situ Biodegradation System									
Balance of Capital Costs, In Situ Treatment	LS	1	--	17,183.00	/EA	1	EA	20,000	20,000
Treatment Facility, In Situ Bio	LS	1	--	22,291.00	/EA	1	EA	25,000	25,000
Collection System, In Situ Bio	LS	1	--	5,089.00	/EA	1	EA	6,000	6,000
In Situ Biodegradation Unit	LS	1	--	5,200.00	/EA	1	EA	6,000	6,000
Phase II, Treatment System									
Balance of Capital Costs, Phase II	LS	10	--	320,614.00	/EA	1	EA	366,000	236,000
Treatment Facility, 1500 Square Feet	LS	10	--	84,324.00	/EA	1	EA	96,000	62,000
Collection System, Phase II	LS	10	--	55,273.00	/EA	1	EA	63,000	41,000
Hardness/Iron Treatment Unit, Phase II	LS	10	--	2,600.00	/EA	1	EA	3,000	2,000
Air Stripping Unit	LS	10	--	20,942.00	/EA	1	EA	24,000	15,000
Emissions Treatment Unit	LS	10	--	54,430.00	/EA	1	EA	62,000	40,000
Granular Activated Carbon Adsorption Unit	LS	10	--	58,740.00	/EA	1	EA	67,000	43,000
Subtotal (A)								4,493,000	3,628,000
COST CODE HMSS									
INDIRECT CAPITAL COSTS									
Mob/Demob 5.1% B = 0.051 * (A)								230,000	186,000
Indirects, Overhead & Profit 41.5% C = 0.415 * (A+B)								1,960,000	1,583,000
Engineering Design 4.5% D = 0.045 * (A+B+C)								301,000	243,000
Resident Engineering 2.0% E = 0.020 * (A+B+C+D)								140,000	113,000
Contingency 31.3% F = 0.313 * (A+B+C+D)								2,183,000	1,763,000
Subtotal (G =B+C+D+E+F)								4,814,000	3,887,000
TOTAL CAPITAL COSTS (H = A+G)								9,307,000	7,516,000

Table A5-9 Cost Estimate - South Plants Plume Group

Alternative SPC-7/SPT-2/SPT-5: Mass Reduction/Dewatering, Air Stripping/GAC Adsorption, In Situ Biodegradation

Cost Item	Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Annual Cost Yr 1-5	1995 ($) Annual Cost Yr 6-10	1995 ($) Annual Cost Yr 11-30	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT O&M COSTS (OPERATIONS)												
Phase I, Control System												
Maintenance & Repair	A	1	10	85,321.00	/EA-YR	1	EA	97,000	97,000		974,000	789,000
Well & Pump Operations	A	1	10	5,138.00	/EA-YR	1	EA	6,000	6,000		59,000	48,000
Maintenance & Repair, LNAPL	A	1	5	1,360.00	/EA-YR	1	EA	2,000			8,000	7,000
Well & Pump Operations, LNAPL	A	1	5	510.00	/EA-YR	1	EA	1,000			3,000	3,000
Phase II, Control System												
Maintenance & Repair	A	11	30	88,596.00	/EA-YR	1	EA			101,000	2,022,000	812,000
Well & Pump Operations	A	11	30	6,931.00	/EA-YR	1	EA			8,000	158,000	64,000
Well System & Plume Evaluation Monitoring	A	1	30	121,258.00	/EA-YR	1	EA	138,000	138,000	138,000	4,151,000	2,200,000
Phase I, Treatment System												
Collection System	A	1	10	1,118.00	/EA-YR	1	EA	1,000	1,000		13,000	10,000
Hardness/Iron Treatment Unit	A	1	10	1.00	/EA-YR	1	EA	1	1		11	9
Granular Activated Carbon Adsorption Unit	A	1	10	6,521.00	/EA-YR	1	EA	7,000	7,000		74,000	60,000
Light Non-Aqueous Phase Liquid Disposal	A	1	5	2,876.00	/EA-YR	1	EA	3,000			16,000	15,000
In Situ Biodegradation System												
Treatment Facility, In Situ Bio	A	1	10	3,139.00	/EA-YR	1	EA	4,000	4,000		36,000	29,000
Collection System, In Situ Bio	A	1	10	5,268.00	/EA-YR	1	EA	6,000	6,000		60,000	49,000
In Situ Biodegradation Unit	A	1	10	11,892.00	/EA-YR	1	EA	14,000	14,000		136,000	110,000
Process Monitoring, In Situ Bio	A	1	10	15,116.00	/EA-YR	1	EA	17,000	17,000		172,000	140,000
Phase II, Treatment System												
Treatment Facility, 1500 Square Feet	A	11	30	4,339.00	/EA-YR	1	EA			5,000	99,000	40,000
Collection System, Phase II	A	11	30	41,750.00	/EA-YR	1	EA			48,000	953,000	383,000
Hardness/Iron Treatment Unit, Phase II	A	11	30	9,663.00	/EA-YR	1	EA			11,000	221,000	89,000
Air Stripping Unit	A	11	30	25,809.00	/EA-YR	1	EA			29,000	589,000	237,000
Emissions Treatment Unit	A	11	30	33,014.00	/EA-YR	1	EA			38,000	753,000	303,000
Granular Activated Carbon Adsorption Unit	A	11	30	19,727.00	/EA-YR	1	EA			23,000	450,000	181,000
Process Monitoring	A	11	30	49,896.00	/EA-YR	1	EA			57,000	1,139,000	457,000
Subtotal (I)								296,001	290,001	458,000	12,086,000	6,024,000
COST CODE LMSL												
INDIRECT O&M COSTS (OPERATIONS)												
Indirects, Overhead & Profit 39.0% J = 0.390 * (I)								115,000	113,000	179,000	4,714,000	2,349,000
Resident Engineering 2.0% K = 0.020 * (I+J)								8,000	8,000	13,000	336,000	167,000
Contingency 31.3% L = 0.313 * (I+J+K)								131,000	128,000	203,000	5,355,000	2,669,000
Subtotal (O = J+K+L)								254,000	249,000	395,000	10,405,000	5,186,000
TOTAL O&M COSTS (T = I+O)								550,000	539,000	853,000	22,491,000	11,210,000
TOTAL CAPITAL COSTS AND TOTAL O&M COSTS (U = H+T)											31,800,000	18,700,000

Table A5-10 Cost Estimate - South Plants Plume Group

Alternative SPC-7/SPT-3/SPT-5: Mass Reduction/Dewatering, Oxidation/GAC Adsorption, In Situ Biodegradation

Cost Item	Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT CAPITAL COSTS									
Phase I. Control System									
Extraction Wells & Pump Installation	LS	1	--	507,601.00	/EA	1	EA	579,000	579,000
Injection Well Installation	LS	1	--	264,929.00	/EA	1	EA	302,000	302,000
Performance Monitoring Well Installation	LS	1	--	376,730.00	/EA	1	EA	430,000	430,000
Extraction Pipe & System Installation	LS	1	--	281,517.00	/EA	1	EA	321,000	321,000
Reinjection Pipe & System Installation	LS	1	--	121,863.00	/EA	1	EA	139,000	139,000
Recharge Trench Installation	LS	1	--	174,000.00	/EA	1	EA	199,000	199,000
Extraction Wells & Pump Installation, LNAPL	LS	1	--	19,818.00	/EA	1	EA	23,000	23,000
Phase II. Control System									
Extraction Wells & Pump Installation	LS	10	--	794,223.00	/EA	1	EA	906,000	584,000
Performance Monitoring Well Installation	LS	10	--	215,874.00	/EA	1	EA	246,000	159,000
Extraction Pipe & System Installation	LS	10	--	525,525.00	/EA	1	EA	600,000	387,000
Phase I. Treatment System									
Balance of Capital Costs, Phase I	LS	1	--	5,325.00	/EA	1	EA	6,000	6,000
Collection System	LS	1	--	22.00	/EA	1	EA	25	25
Light Non-Aqueous Phase Liquid Disposal	LS	1	--	3,370.00	/EA	1	EA	4,000	4,000
In Situ Biodegradation System									
Balance of Capital Costs, In Situ Treatment	LS	1	--	17,183.00	/EA	1	EA	20,000	20,000
Treatment Facility, In Situ Bio	LS	1	--	22,291.00	/EA	1	EA	25,000	25,000
Collection System, In Situ Bio	LS	1	--	5,089.00	/EA	1	EA	6,000	6,000
In Situ Biodegradation Unit	LS	1	--	5,200.00	/EA	1	EA	6,000	6,000
Phase II. Treatment System									
Balance of Capital Costs, Phase II	LS	10	--	378,012.00	/EA	1	EA	431,000	278,000
Treatment Facility, 1500 Square Feet	LS	10	--	84,324.00	/EA	1	EA	96,000	62,000
Collection System, Phase II	LS	10	--	55,773.00	/EA	1	EA	64,000	41,000
Oxidation Unit	LS	10	--	110,217.00	/EA	1	EA	126,000	81,000
Emissions Treatment Unit	LS	10	--	2,865.00	/EA	1	EA	3,000	2,000
Granular Activated Carbon Adsorption Unit	LS	10	--	57,500.00	/EA	1	EA	66,000	42,000
Subtotal (A)								4,598,000	3,696,000
COST CODE HMSS									
INDIRECT CAPITAL COSTS									
Mob/Demob 5.1% B = 0.051 • (A)								236,000	189,000
Indirects, Overhead & Profit 41.5% C = 0.415 • (A+B)								2,006,000	1,612,000
Engineering Design 4.5% D = 0.045 • (A+B+C)								308,000	247,000
Resident Engineering 2.0% E = 0.020 • (A+B+C+D)								143,000	115,000
Contingency 31.3% F = 0.313 • (A+B+C+D)								2,234,000	1,795,000
Subtotal (G =B+C+D+E+F)								4,926,000	3,960,000
TOTAL CAPITAL COSTS (H = A+G)								9,524,000	7,655,000

Table A5-10 Cost Estimate - South Plants Plume Group
Alternative SPC-7/SPT-3/SPT-5: Mass Reduction/Dewatering, Oxidation/GAC Adsorption, In Situ Biodegradation

Cost Item	Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Annual Cost Yr 1-5	1995 ($) Annual Cost Yr 6-10	1995 ($) Annual Cost Yr 11-30	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT O&M COSTS (OPERATIONS)												
Phase I, Control System												
Maintenance & Repair	A	1	10	85,321.00	/EA-YR	1	EA	97,000	97,000		974,000	789,000
Well & Pump Operations	A	1	10	5,138.00	/EA-YR	1	EA	6,000	6,000		59,000	48,000
Maintenance & Repair, LNAPL	A	1	5	1,360.00	/EA-YR	1	EA	2,000			8,000	7,000
Well & Pump Operations, LNAPL	A	1	5	510.00	/EA-YR	1	EA	1,000			3,000	3,000
Phase II, Control System												
Maintenance & Repair	A	11	30	88,596.00	/EA-YR	1	EA			101,000	2,022,000	812,000
Well & Pump Operations	A	11	30	6,931.00	/EA-YR	1	EA			8,000	158,000	64,000
Well System & Plume Evaluation Monitoring	A	1	30	121,258.00	/EA-YR	1	EA	138,000	138,000	138,000	4,151,000	2,200,000
Phase I, Treatment System												
Collection System	A	1	10	1,118.00	/EA-YR	1	EA	1,000	1,000		13,000	10,000
Hardness/Iron Treatment Unit	A	1	10	1.00	/EA-YR	1	EA	1	1		11	9
Granular Activated Carbon Adsorption Unit	A	1	10	6,521.00	/EA-YR	1	EA	7,000	7,000		74,000	60,000
Light Non-Aqueous Phase Liquid Disposal	A	1	5	2,876.00	/EA-YR	1	EA	3,000			16,000	15,000
In Situ Biodegradation System												
Treatment Facility, In Situ Bio	A	1	10	3,139.00	/EA-YR	1	EA	4,000	4,000		36,000	29,000
Collection System, In Situ Bio	A	1	10	5,268.00	/EA-YR	1	EA	6,000	6,000		60,000	49,000
In Situ Biodegradation Unit	A	1	10	11,892.00	/EA-YR	1	EA	14,000	14,000		136,000	110,000
Process Monitoring, In Situ Bio	A	1	10	15,116.00	/EA-YR	1	EA	17,000	17,000		172,000	140,000
Phase II, Treatment System												
Treatment Facility, 1500 Square Feet	A	11	30	4,339.00	/EA-YR	1	EA			5,000	99,000	40,000
Collection System, Phase II	A	11	30	41,750.00	/EA-YR	1	EA			48,000	953,000	383,000
Oxidation Unit	A	11	30	44,384.00	/EA-YR	1	EA			51,000	1,013,000	407,000
Emissions Treatment Unit	A	11	30	33,856.00	/EA-YR	1	EA			39,000	773,000	310,000
Granular Activated Carbon Adsorption Unit	A	11	30	11,644.00	/EA-YR	1	EA			13,000	266,000	107,000
Process Monitoring	A	11	30	49,896.00	/EA-YR	1	EA			57,000	1,139,000	457,000
Subtotal (I)								296,001	290,001	460,000	12,124,000	6,039,000
COST CODE LMSL												
INDIRECT O&M COSTS (OPERATIONS)												
Indirects, Overhead & Profit 39.0% J = 0.390 * (I)								115,000	113,000	179,000	4,728,000	2,355,000
Resident Engineering 2.0% K = 0.020 * (I+J)								8,000	8,000	13,000	337,000	168,000
Contingency 31.3% L = 0.313 * (I+J+K)								131,000	128,000	204,000	5,372,000	2,676,000
Subtotal (O = J+K+L)								254,000	249,000	396,000	10,437,000	5,199,000
TOTAL O&M COSTS (T = I+O)								550,000	539,000	856,000	22,562,000	11,239,000
TOTAL CAPITAL COSTS AND TOTAL O&M COSTS (U = H+T)											32,100,000	18,900,000

Table A6-1 Cost Estimate - Combined Basin A and South Plants Plume Group
Alternative AC-3/AT-2, SPC-7/SPT-2/SPT-5: Mass Reduction/Dewatering, Air Stripping/GAC Adsorption, In Situ Biodegradation

Cost Item	Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT CAPITAL COSTS									
Phase I, Control System									
Extraction Wells & Pump Installation	LS	1	--	596,112.00	/EA	1	EA	680,000	680,000
Performance Monitoring Well Installation	LS	1	--	411,805.00	/EA	1	EA	470,000	470,000
Extraction Pipe & System Installation	LS	1	--	557,235.00	/EA	1	EA	636,000	636,000
Extraction Wells & Pump Installation	LS	1	--	507,601.00	/EA	1	EA	579,000	579,000
Injection Well Installation	LS	1	--	264,929.00	/EA	1	EA	302,000	302,000
Performance Monitoring Well Installation	LS	1	--	376,730.00	/EA	1	EA	430,000	430,000
Extraction Pipe & System Installation	LS	1	--	281,517.00	/EA	1	EA	321,000	321,000
Reinjection Pipe & System Installation	LS	1	--	121,863.00	/EA	1	EA	139,000	139,000
Recharge Trench Installation	LS	1	--	174,000.00	/EA	1	EA	199,000	199,000
Extraction Wells & Pump Installation, LNAPL	LS	1	--	19,818.00	/EA	1	EA	23,000	23,000
Phase II, Control System									
Extraction Wells & Pump Installation	LS	10	--	794,223.00	/EA	1	EA	906,000	584,000
Performance Monitoring Well Installation	LS	10	--	215,874.00	/EA	1	EA	246,000	159,000
Extraction Pipe & System Installation	LS	10	--	525,525.00	/EA	1	EA	600,000	387,000
Phase I, Treatment System									
Balance of Capital Costs, Combined Phase I	LS	1	--	301,663.00	/EA	1	EA	344,000	344,000
Treatment Facility, 1500 Square Feet	LS	1	--	84,324.00	/EA	1	EA	96,000	96,000
Hardness/Iron Treatment Unit	LS	1	--	2,600.00	/EA	1	EA	3,000	3,000
Air Stripping Unit	LS	1	--	18,881.00	/EA	1	EA	22,000	22,000
Emissions Treatment Unit	LS	1	--	46,900.00	/EA	1	EA	54,000	54,000
Granular Activated Carbon Adsorption Unit	LS	1	--	57,484.00	/EA	1	EA	66,000	66,000
Collection System, Phase I	LS	1	--	54,772.00	/EA	1	EA	62,504	62,504
Light Non-Aqueous Phase Liquid Disposal	LS	1	--	3,370.00	/EA	1	EA	4,000	4,000
In Situ Biodegradation System									
Balance of Capital Costs, In Situ Treatment	LS	1	--	17,183.00	/EA	1	EA	20,000	20,000
Treatment Facility, In Situ Bio	LS	1	--	22,291.00	/EA	1	EA	25,000	25,000
Collection System, In Situ Bio	LS	1	--	5,089.00	/EA	1	EA	6,000	6,000
In Situ Biodegradation Unit	LS	1	--	5,200.00	/EA	1	EA	6,000	6,000
Phase II, Treatment System									
Balance of Capital Costs, Combined Phase II	LS	11	--	113,678.00	/EA	1	EA	130,000	80,000
Air Stripping Unit	LS	11	--	17,227.00	/EA	1	EA	20,000	12,000
Emissions Treatment Unit	LS	11	--	54,430.00	/EA	1	EA	62,000	38,000
Granular Activated Carbon Adsorption Unit	LS	11	--	37.00	/EA	1	EA	0	0
Collection System, Phase II	LS	11	--	712.00	/EA	1	EA	813	499
Subtotal (A)								6,451,000	5,746,000
COST CODE HMSS									
INDIRECT CAPITAL COSTS									
Mob/Demob 5.1% B = 0.051 * (A)								331,000	294,000
Indirects, Overhead & Profit 41.5% C = 0.415 * (A+B)								2,814,000	2,507,000
Engineering Design 4.5% D = 0.045 * (A+B+C)								432,000	385,000
Resident Engineering 2.0% E = 0.020 * (A+B+C+D)								201,000	179,000
Contingency 31.3% F = 0.313 * (A+B+C+D)								3,134,000	2,791,000
Subtotal (G = B+C+D+E+F)								6,911,000	6,156,000
TOTAL CAPITAL COSTS (H = A+G)								13,362,000	11,902,000

Table A6-1 Cost Estimate - Combined Basin A and South Plants Plume Group
Alternative AC-3/AT-2, SPC-7/SPT-2/SPT-5: Mass Reduction/Dewatering, Air Stripping/GAC Adsorption, In Situ Biodegradation

Cost Item	Cost Type	Start Year	End Year	1992 ($) Unit Cost	Units	Quantity	Units	1995 ($) Annual Cost Yr 1-5	1995 ($) Annual Cost Yr 6-10	1995 ($) Annual Cost Yr 11-30	1995 ($) Total Cost	1995 ($) PW Cost
DIRECT O&M COSTS (OPERATIONS)												
Phase I, Control System												
Maintenance & Repair	A	1	10	57,035.00	/EA-YR	1	EA	65,000	65,000		651,000	528,000
Well & Pump Operations	A	1	10	4,153.00	/EA-YR	1	EA	5,000	5,000		47,000	38,000
Well System & Plume Evaluation Monitoring	A	1	30	96,303.00	/EA-YR	1	EA	110,000	110,000	110,000	3,297,000	1,747,000
Maintenance & Repair	A	1	10	85,321.00	/EA-YR	1	EA	97,000	97,000		974,000	789,000
Well & Pump Operations	A	1	10	5,138.00	/EA-YR	1	EA	6,000	6,000		59,000	48,000
Maintenance & Repair, LNAPL	A	1	5	1,360.00	/EA-YR	1	EA	2,000			8,000	7,000
Well & Pump Operations, LNAPL	A	1	5	510.00	/EA-YR	1	EA	1,000			3,000	3,000
Phase II, Control System												
Maintenance & Repair	A	11	30	88,596.00	/EA-YR	1	EA			101,000	2,022,000	812,000
Well & Pump Operations	A	11	30	6,931.00	/EA-YR	1	EA			8,000	158,000	64,000
Well System & Plume Evaluation Monitoring	A	1	30	121,258.00	/EA-YR	1	EA	138,000	138,000	138,000	4,151,000	2,200,000
Phase I, Treatment												
Treatment Facility, 1500 Square Feet	A	1	10	4,339.00	/EA-YR	1	EA	5,000	5,000		50,000	40,000
Collection System, Phase I	A	1	10	34,484.00	/EA-YR	1	EA	39,000	39,000		394,000	319,000
Hardness/Iron Treatment Unit	A	1	10	9,657.00	/EA-YR	1	EA	11,000	11,000		110,000	89,000
Air Stripping Unit	A	1	10	19,695.00	/EA-YR	1	EA	22,000	22,000		225,000	182,000
Emissions Treatment Unit	A	1	10	32,495.00	/EA-YR	1	EA	37,000	37,000		371,000	301,000
Granular Activated Carbon Adsorption Unit	A	1	10	64,454.00	/EA-YR	1	EA	74,000	74,000		736,000	596,000
Process Monitoring	A	1	10	78,096.00	/EA-YR	1	EA	89,000	89,000		891,000	723,000
Continued Operation of Basin A Neck IRA	A	1	30	478,000.00	/EA-YR	1	EA	545,000	545,000	545,000	16,364,000	8,672,000
Light Non-Aqueous Phase Liquid Disposal	A	1	5	2,876.00	/EA-YR	1	EA	3,000			16,000	15,000
In Situ Biodegradation System												
Treatment Facility, In Situ Bio	A	1	10	3,139.00	/EA-YR	1	EA	4,000	4,000		36,000	29,000
Collection System, In Situ Bio	A	1	10	5,268.00	/EA-YR	1	EA	6,000	6,000		60,000	49,000
In Situ Biodegradation Unit	A	1	10	11,892.00	/EA-YR	1	EA	14,000	14,000		136,000	110,000
Process Monitoring, In Situ Bio	A	1	10	15,116.00	/EA-YR	1	EA	17,000	17,000		172,000	140,000
Phase II, Treatment System												
Treatment Facility, 1500 Square Feet	A	11	30	4,339.00	/EA-YR	1	EA			5,000	99,000	40,000
Collection System, Phase II	A	11	30	41,750.00	/EA-YR	1	EA			48,000	953,000	383,000
Hardness/Iron Treatment Unit, Phase II	A	11	30	9,663.00	/EA-YR	1	EA			11,000	221,000	89,000
Air Stripping Unit	A	11	30	25,809.00	/EA-YR	1	EA			29,000	589,000	237,000
Emissions Treatment Unit	A	11	30	33,014.00	/EA-YR	1	EA			38,000	753,000	303,000
Granular Activated Carbon Adsorption Unit	A	11	30	19,727.00	/EA-YR	1	EA			23,000	450,000	181,000
Process Monitoring	A	11	30	49,896.00	/EA-YR	1	EA			57,000	1,139,000	457,000
Subtotal (I)								1,290,000	1,284,000	1,113,000	35,134,000	19,189,000
COST CODE LMSL												
INDIRECT O&M COSTS (OPERATIONS)												
Indirects, Overhead & Profit 39.0% J = 0.390 * (I)								503,000	501,000	434,000	13,702,000	7,484,000
Resident Engineering 2.0% K = 0.020 * (I+J)								36,000	36,000	31,000	977,000	533,000
Contingency 31.3% L = 0.313 * (I+J+K)								572,000	569,000	493,000	15,567,000	8,502,000
Subtotal (O = J+K+L)								1,111,000	1,106,000	958,000	30,246,000	16,519,000
TOTAL O&M COSTS (T = I+O)								2,401,000	2,390,000	2,071,000	65,380,000	35,708,000
TOTAL CAPITAL COSTS AND TOTAL O&M COSTS (U = H+T)											78,700,000	47,600,000

SP-11.WQ1
WATER DAA

08-Jul-93

TABLE A4.0-1
MARKUP MATRIX
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09-Jul-93

CAPITAL COST

CONSIDERATION FACTORS	LEVEL	EXAMPLES	MOB/ DEMOB	INDIRECTS O&P	DESIGN ENGR	RESIDENT ENGR	CNTGNCY
CONTAMINATION	Low	Level D or no protection Up to 10% Level C No Level A or B	2.00%	34.00%		1.00%	25.00%
	Medium	From 10% to 25% Level C No Level A or B	4.50%	39.00%		2.00%	30.00%
	High	26% or greater Level C Level A or B	7.00%	44.00%		3.00%	40.00%
TECHNOLOGY	Low	Excavation, backfill, transportation, normal civil/structural construction Vapor Extraction, Landfill	2.00%	39.00%	3.00%	1.00%	25.00%
	Medium	Demolition, Proven Decon Methods, Pump & & Treat Facilities, Mech & Elect Const, UXO D&D Solidification	4.50%	39.00%	4.50%	2.00%	30.00%
	High	Incineration, Thermal Desorption In-Situ Vitrification, Unproven Decon Methods	7.00%	39.00%	6.50%	3.00%	40.00%
JOB SIZE	Small	Less than 20 Craft personnel	4.50%	44.00%		2.00%	30.00%
	Medium	20 to 60 Craft personnel	4.50%	39.00%		2.00%	30.00%
	Large	More than 60 Craft personnel	4.50%	34.00%		2.00%	30.00%
DURATION	Short	< 3 Years	4.50%	39.00%		1.00%	25.00%
	Medium	3 to 7 Years	4.50%	39.00%		2.00%	30.00%
	Long	> 7 Years	4.50%	39.00%		3.00%	40.00%

TABLE A4.0-1
MARKUP MATRIX
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09-Jul-93

O&M COST

CONSIDERATION FACTORS	LEVEL	EXAMPLES	INDIRECTS O&P	RESIDENT ENGR	CNTGNCY
CONTAMINATION	Low	Level D or no protection Up to 10% Level C No Level A or B	34.00%	1.00%	25.00%
	Medium	From 10% to 25% Level C No Level A or B	39.00%	2.00%	30.00%
	High	26% or greater Level C Level A or B	44.00%	3.00%	40.00%
TECHNOLOGY	Low	Excavation, backfill, transportation, normal civil/structural construction Vapor Extraction, Landfill	39.00%	1.00%	25.00%
	Medium	Demolition, Proven Decon Methods, Pump & & Treat Facilities, Mech & Elect Const, UXO D&D Solidification	39.00%	2.00%	30.00%
	High	Incineration, Thermal Desorption In-Situ Vitrification, Unproven Decon Methods	39.00%	3.00%	40.00%
JOB SIZE	Small	Less than 20 Craft personnel	44.00%	2.00%	30.00%
	Medium	20 to 60 Craft personnel	39.00%	2.00%	30.00%
	Large	More than 60 Craft personnel	34.00%	2.00%	30.00%
DURATION	Short	< 3 Years	39.00%	1.00%	25.00%
	Medium	3 to 7 Years	39.00%	2.00%	30.00%
	Long	> 7 Years	39.00%	3.00%	40.00%